APPENDIX XXVI

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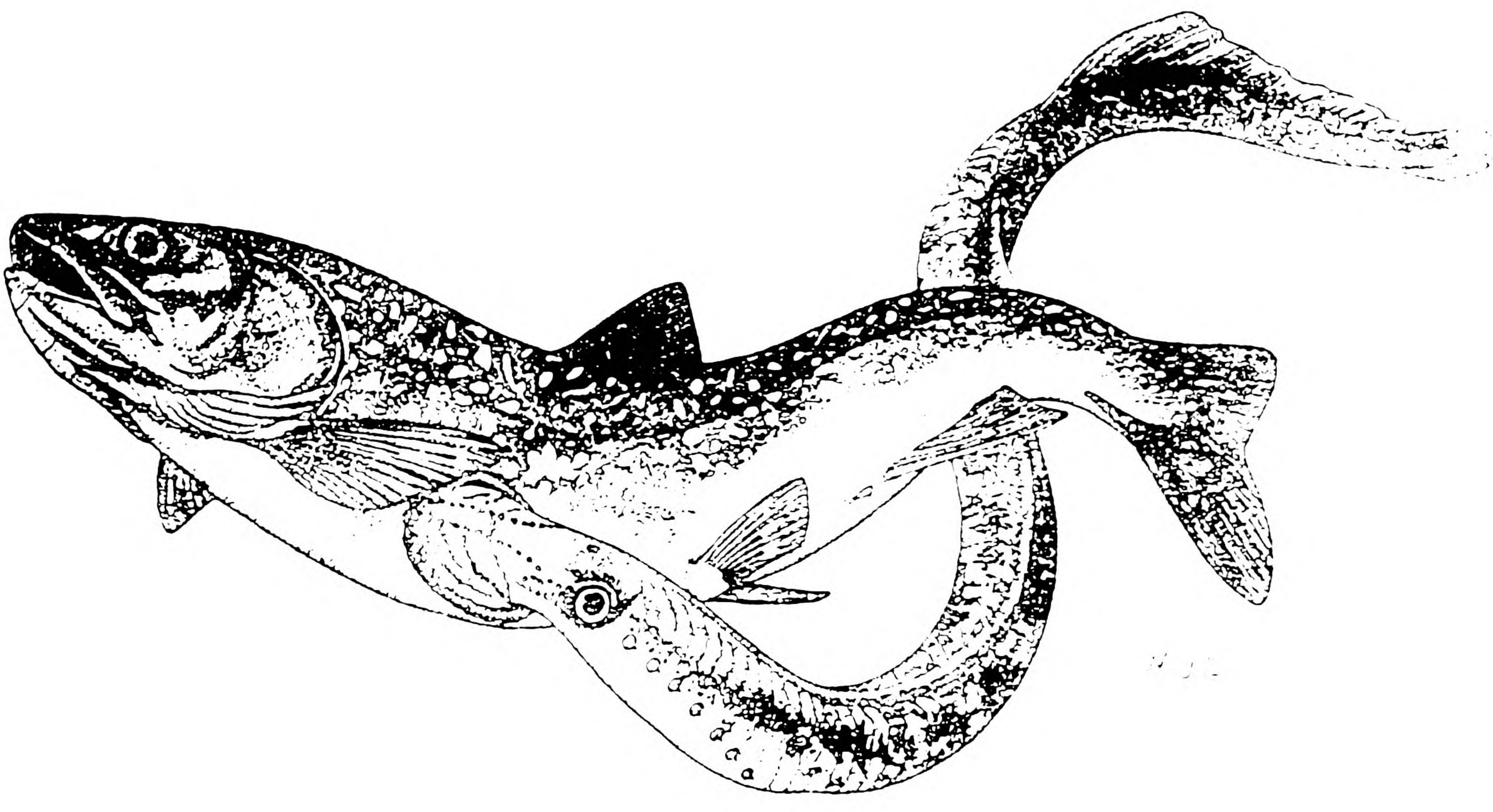
SEA LAMPREY MANAGEMENT IN THE GREAT LAKES IN 1988

ANNUAL REPORT

TO

GREAT LAKES FISHERY COMMISSION



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This is a joint report that summarizes sea lamprey management and control efforts conducted by the United States Fish and Wildlife Service and the Department of Fisheries and Oceans of Canada. The 1988 management activities include: larval assessment, chemical treatment, spawning-phase assessment, parasitic-phase assessment, construction of low-head barrier dams, and assessment of the effects of lampricides on nontarget organisms. Larval assessment surveys were completed on 400 Great Lakes tributaries. A chemical survey was conducted in a side channel near the the Little Rapids Cut on the St. Marys River and an estimated 255,000 sea lampreys (244,000 larvae and 11,000 transforming larvae) were present. Chemical treatments were completed on 69 tributaries to the Great Lakes (Table 1). In U.S. waters, 14 chemical treatments on rivers and streams were postponed because of low water levels. In Canadian waters, four chemical treatments were postponed on tributaries to the Great Lakes. Assessment traps placed in 62 tributaries to the Great Lakes captured 69,130 spawning-phase sea lampreys (Table 2). A total of 5,900 parasitic-phase sea lampreys were collected from commercial and sport fishermen in the Upper Great Lakes. Tests of the short-term effects of lampricides on nontarget organisms were conducted in treated and control sections of two streams in two lake basins. Long-term monitoring of the effects of lampricides to the mayfly <u>*Hexagenia*</u> *and other organisms continued in four streams.*

LAKE SUPERIOR

LARVAL ASSESSMENT

United States

Surveys monitored reestablished and residual larval populations, prepared for chemical treatments, and searched for new infestations on 70 Lake Superior tributaries. Sea lampreys had reestablished in at least 36 streams.

Surveys to assess recruitment of the 1988 year class were conducted in 62 streams and young-of-the-year larvae were recovered in 22. Recruitment was relatively light to moderate in most cases except for the Two Hearted and Amnicon rivers. Surveys of index sites in 1988 were reduced by excluding 21 streams which have not shown infestation for 10 or more years. In the future, these streams will be examined every three years. No recruitment of young-of-the-year has occurred for five or more years in the Laughing Whitefish, Dead, Slate, Big Gratiot, Poplar (Wisconsin), and Gooseberry rivers, and Munising Falls and Eliza creeks. Surveys to schedule (pretreatment) or evaluate (posttreatment) the lampricide treatments were conducted on 26 streams.

Table 1. Summary of chemical treatments in streams of the Great Lakes in 1988.

[Lampricides used are in kilograms/pound of active ingredient.]

Lake	Number of Streams	Discharge m^3/s	Discharge f^3/s	TFM[a] kg	TFM[a] lbs	Bayer 73 Powder kg	Bayer 73 Powder lbs	Stre[am] trea[ted] km	m[i]
Superior	20	101.0	3,568	14,559	32,099	73.4	161.8	620.0	
Michigan	22	61.0	2,157	13,123	29,211	11.3	25.0	427.4	
Huron	16	67.2	2,313	11,257	24,816	4.9	10.8	268.9	
Erie	0	-	-	-	-	-	-	-	
Ontario	11	5.5	192	1,519	3,348	-	-	107.8	
Total	69	234.7	8,230	40,458	89,474	89.6	197.6	1,424	

[a]Includes 1385 TFM bars (289.7 kg, 636.7 lbs) applied in 21 streams.

[Tab]le 2. Number and biological characteristics of adult sea lampreys captured in assessment traps in 62 tributaries of the Great lakes in 1988.

Lake	Number of streams	Total captured	Number sampled	Percent males	Mean length (mm) Males	Mean length (mm) Females	Mean weigh[t] Males	Fe[males]
Superior	21	4,018	1,147	35	430	430	188	[illegible]
Michigan	11	16,776	2,051	40	494	495	261	[illegible]
Huron	11	40,866	3,431	53	483	482	251	[illegible]
Erie	3	1,903	1,357	63	506	501	301	[illegible]
Ontario	16	5,567	1,759	53	477	474	258	

Pretreatment surveys were conducted on 20 streams, 11 for 1988 treatment (8 later were successfully treated) and 9 for 1989-90 treatment. Posttreatment surveys were conducted on six tributaries to assess treatments of 1987-88. Residual sea lampreys were collected in the Tahquamenon, Little Two Hearted, and Two Hearted rivers.

Other surveys found residual lampreys in 16 additional streams. The number of residual lampreys in any of the collections was less than 10% of the total number of larvae in the populations and indicates successful treatment.

Lentic surveys were performed in offshore areas or inland lakes of the Silver, Falls and Ravine rivers and Harlow Creek. Sea lampreys were collected on the Silver (5 larvae; 49-63 mm) and Falls (1,250 larvae; 38-177 mm) rivers, and Harlow Creek (2 larvae; 92-146 mm). A moderate lentic population exists in L'Anse Bay offshore of the Falls River and indicates the out-migration of larvae prior to past treatments of the stream.

Population estimates of larval sea lampreys were conducted in two tributaries (Huron River and Harlow Creek) of Lake Superior in 1988. The focus of the study was to develop and evaluate several quantitative methods of estimating populations of larval sea lampreys and to select an estimate model that produces results within a reasonable degree of confidence. The techniques included a habitat based inventory with two estimates of larval densities and three variations of the Petersen mark and recapture method (Table 3).

Table 3. Population estimates of larval sea lampreys in the Huron River and Harlow Creek (Lake Superior) by two methods of habitat based inventory and through variations of mark and recapture techniques, 1988. (The 95% confidence intervals are in parentheses.)

Method	Estimate	
Habitat Inventory	Huron River	Harlow Creek
Observed Density	484,018 (415,018 - 553,018)	62,000 (10,349 - 113,651)
Depletion	614,869 (372,263 - 857,475)	62,100 (45,270 - 78,930)
Mark and Recapture		
Run - A	260,369 (181,369 - 339,369)	53,473 (29,656 - 77,290)
Run - B	354,057 (266,322 - 441,792)	78,000 (57,517 - 98,483)
Combined	321,081 (259,916 - 382,246)	68,000 (47,900 - 88,100)

For the habitat based estimates, two parameters were defined: the amour of larval habitat (substrate) within the stream and the larval density withi that habitat. Substrates were sampled by selecting transects across the rive at 300 foot intervals, measuring the amount of each substrate type (sand, silt gravel, etc) on the transect plane, and then categorizing the substrate into or of three broad categories of larval habitat: type I (optimum), type I (acceptable, but less than optimum), and type III, (uninhabitable). At eac transect, densities of larvae were estimated for each habitat type by tw methods: single sample with the backpack shocker (observed density), an depletion sampling (3 or more replicates). Habitat types and densities of larva were estimated by location and then summed to develop total stream estimates b the two habitat based methods (Table 3). The estimates were within ranges c the 95% confidence intervals in the Huron River and near identical in Harlo Creek.

Traditional mark and recapture methods were used during lampricic treatments on both tributaries. Larvae were captured throughout the stream wit electrofishing gear, marked with a dye and released back into the stream. Th larvae were recaptured during chemical treatments and three estimates wer derived for each river by a modified Petersen formula (Table 3). Primarily these estimates were conducted to verify the habitat based methods. The per-centage of transformed lampreys found by collections during treatments were Huron River - 0.4% and Harlow Creek - 3.3%.

Much of the variability in the population estimates was the result of th variation in the density of larvae, time of year, and collection conditions Density of larvae was more variable in type I than type II habitat. Young-of the-year larvae were present in the Huron River during the depletion samplin but not for estimates by observed densities. Collection conditions were poo because of high water for the collection phase of the mark and recapture trial on both rivers.

Depletion sampling, combined with habitat surveys, appears to be the bes approach to estimate lamprey populations of those methods that were tested. Th observed density estimates, while apparently adequate for the present streams rely heavily on capture efficiency of the electrofishing gear and collectic conditions such as cloud cover, water turbidity, and water velocity. The mar and recapture estimates are not suitable because they were conducted i conjunction with the treatments, and would not be useful as a prediction too to schedule treatment. Advantages of population estimates derived from the us of depletion and habitat based methods are as follows: provides statisticall sound estimate of population and variance; gear efficiency is not critica provided probability of capture remains constant among sample runs; larvae woul be handled only at time of initial capture; more efficient use of man power and, with modification, the approach can be applied to all U.S. tributaries c Lake Superior.

Canada

Surveys conducted on 27 tributaries and 17 stream delta areas prepared for chemical treatments in 1989, monitored reestablished, residual and untreated populations, and searched for new infestations. An estimate of larval and transforming sea lamprey abundance was made in one large tributary.

Distribution surveys completed on 11 streams recommended for treatment in 1989 showed no significant changes in the distribution from that of earlier years.

Surveys to evaluate 1987 treatments (Stillwater, Polly, and Cash creeks and Kaministiquia, Little Gravel, and Little Carp rivers) found no significant residual populations. Only one stream, Cash Creek, appears to have a reestablished 1987 year class. Surveys were done too early to confirm successful 1988 recruitment. Five out of six streams treated in 1986 (Carp, Gravel, Cypress, Michipicoten, and Nipigon rivers) are reestablished with 1986 and 1987 year classes.

Of the 17 lentic areas surveyed in 1988, all but one were stream deltas (areas of sand/silt deposition) off the mouths of sea lamprey producing streams. Significant lentic populations continue to be present in Batchawana Bay off Harmony, Chippewa, Batchawana, and Carp rivers, and in Mountain Bay off the Gravel and Little Gravel rivers. A larval population is building in Nipigon Bay off the Jackpine River following strong instream year class production in 1985 and 1986. The Jackpine River has never been treated with lampricide because suitable larval habitat is confined to the mouth area. The one non-delta lentic area surveyed was Helen Lake, located between the upper and lower Nipigon rivers. Eight index stations on Helen Lake were surveyed with granular Bayer, using the same collecting efforts established in 1987. Each station had an area of 1000 m^2. Surveys in 1988 collected 686 sea lamprey larvae, including two in the early stages of transformation, compared to 501 larvae (0 transformers) in 1987.

The White River was treated in 1988. Larval and transformer sea lamprey populations were estimated. The White River is difficult to survey because of accessibility and water depth. Larval densities appear to be low. Several index plots surveyed with granular Bayer prior to treatment were used to evaluate larval habitat and estimate surface areas. Marked sea lampreys were released before treatment and collected along with unmarked animals during treatment. Overall, larval densities averaged only $0.1/m^2$ in available habitat. An estimated population of 21,322 larvae was derived for the White River, with approximately 2,560 undergoing transformation. Despite the low densities, the White River, at the infestation level found in September 1988, has the potential of contributing a significant number of parasitic-phase sea lampreys into Lake Superior.

CHEMICAL TREATMENTS

United States

Chemical treatments were completed on 14 streams (Table 4, Fig. 1) wit a combined flow of 40.3 m^3/s (1,423 f^3/s). Low water levels and cold weathe caused postponements and cancellation of a number of stream treatments. Lo stream flows on the Bad, Ontonagon, and East Sleeping rivers required additiona chemical application points for successful treatment. The scheduled treatmen of Red Cliff Creek was cancelled due to low stream flow. Treatments of th Arrowhead and Nemadji rivers were cancelled when cold weather caused the PE formulation of TFM to solidify. The lower Sucker River and Galloway Cree treatments were postponed until 1989 to facilitate treatments of higher priorit streams delayed because of low water levels.

Continued failure of the barrier dam on the Misery River to stop adul lampreys required an extensive chemical treatment throughout the river system An abundant larval population of sea lampreys was found above the barrier durin the treatment in 1988.

A high abundance of sea lamprey larvae were found in the Firesteel, Bad Amnicon, Salmon Trout, East Sleeping, Misery, and Huron rivers and a medium t low abundance in the other seven streams. Larvae >120 mm were found in 1 streams. Transforming sea lampreys were present in six of the nine stream treated after mid-July, but most probably were residual lampreys that ha survived previous treatments.

Fish mortality during treatments was low, consisting of trout-perch bullhead spp. and white suckers. Small numbers of mayflies also were killed o a few treatments.

Toxicity tests were conducted on 5 of the 14 streams treated. Tests o four streams confirmed, or were slightly lower than the predicted treatmen range. On the Bad River, tests indicated a significantly higher treatment rang than the recommended range based on total alkalinity of the stream wate (prediction chart). The more conservative chart was used to calculate TFM level during the treatment.

Canada

Chemical treatments were completed on six tributaries (Table 4, Fig. 1) with a combined flow of 60.7 m^3/s (2,145 f^3/s). No treatment occurred on th Batchawana River in 1988 because of excessive water discharge later in th season. All the treatments had low water flows except for the White River. Th lower than average level of Lake Superior in 1988 aided the movement o lampricide blocks through mouth areas. Larval sea lampreys were abundant in th Wolf River, moderately abundant in the Pays Plat and Jackfish rivers, and scarc in the Black Sturgeon, Little Pic, and White rivers. Nontarget fish mortali was negligible in all treatments.

Table 4. Details on the application of lampricides to streams of Lake Superior, 1988.

[Number in parentheses corresponds to location of stream in Figure 1. Lampricides used are in kilograms/pounds of active ingredient.]

Stream or lentic area	Date	Discharge		TFM[a]		Bayer 73 Powder		Stream treated	
		m^3/s	f^3/s	kg	lbs	kg	lbs	km	miles
UNITED STATES									
Waiska R. (1)	May 15	2.8	100	167	369	-	-	37.1	23
Firesteel R. (11)	May 27	1.1	40	313	691	-	-	43.5	27
Amnicon R. (14)	May 27	1.1	38	91	201	-	-	14.5	9
Salmon Trout R. (6)	May 31	1.1	40	186	410	-	-	11.3	7
Bad R. (13)									
Brunsweiler R.	June 10	0.5	16	58	128	-	-	19.4	12
Mainstream	Sept. 2	7.1	250	2,065	4,553	-	-	183.9	114
Ontonagon R. (12)	June 25	12.7	450	2,594	5,719	-	-	129.0	80
Chocolay R. (3)	July 11	3.1	110	613	1,352	-	-	29.0	18
Carp R. (4)	July 14	0.5	17	72	159	-	-	3.2	2
Pendills Cr. (2)	Sept. 16	0.6	21	40	88	-	-	1.6	1
East Sleeping R. (10)	Sept. 29	0.2	7	111	245	-	-	17.7	11
Silver R. (8)	Sept. 30	1.1	39	103	226	-	-	4.8	3
Misery R. (9)	Oct. 1	0.7	25	165	363	-	-	22.6	14
Huron R. (7)	Oct. 5	6.4	225	302	665	-	-	16.1	10
Harlow Cr. (5)	Oct. 18	1.3	45	88	195	-	-	6.5	4
Total		40.3	1,423	6,968	15,364			540.2	335
CANADA									
Wolf R. (15)	July 7	3.2	117	615	1,356	-	-	11.3	7
Pays Plat R. (18)	July 10	1.6	57	171	377	-	-	6.4	4
Jackfish R. (17)	July 14	2.7	95	225	496	3.2	7.1	9.8	6
Black R.									
Sturgeon R. (16)	July 18	15.5	547	1,246	2,747	19.2	42.3	16.2	10
Little Pic R. (19)	Aug. 7	8.2	289	2,057	4,535	-	-	30.7	19
White R. (20)	Sept.10	29.5	1,040	3,277	7,224	51.0	112.4	5.4	3
Total		60.7	2,145	7,591	16,735	73.4	161.8	79.8	49
GRAND TOTAL		101.0	3,568	14,559	32,099	73.4	161.8	620.0	384

[a] Includes 757 TFM bars (158 kg, 348 lbs) applied in 12 streams.

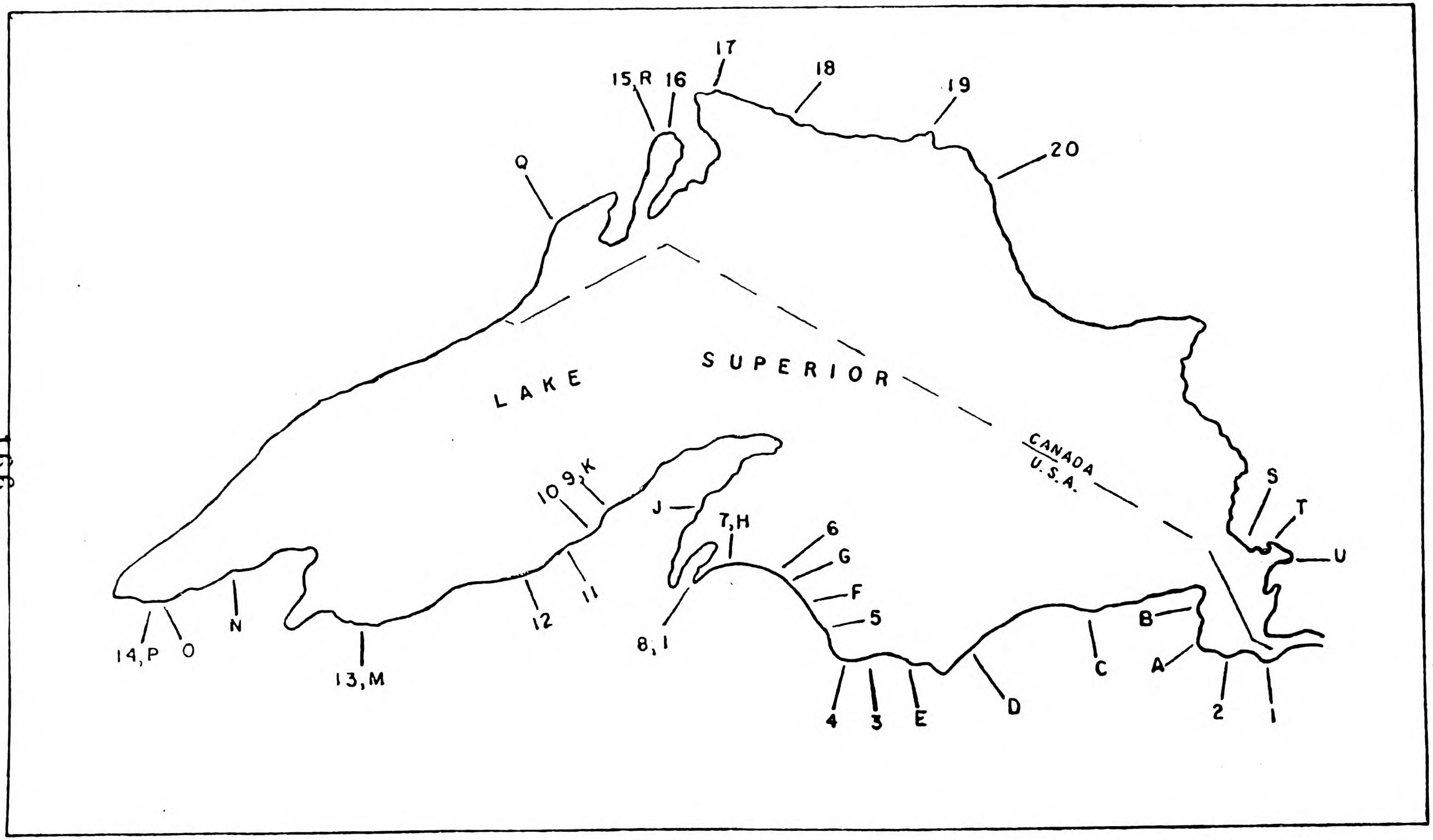

Figure 1. Location of Lake Superior tributaries treated with lampricides (numerals; see Table 4 for names of streams), and of streams where assessment traps were fished (letters; see Table 5 for names of streams) in 1988.

SPAWNING-PHASE ASSESSMENT

United States

Assessment traps placed in 16 tributaries of Lake Superior captured 3,459 adult sea lampreys (Table 5, Fig.1), about the same number taken in 1987 (3,323). Trap catches increased in the Bad, Huron, Big Garlic, and Sucker rivers and decreased in all other tributaries (largest decline occurred in the Brule River, 1,825 vs. 1,260). Hoop-fyke nets placed for the first time in the Firesteel and Traverse rivers captured 17 and 11 sea lampreys, respectively. The average length and weight of lampreys remained about the same as those taken in 1987, but the percentage males declined from 42 to 33%. Spawning runs in nine streams were monitored through cooperative agreements with the Great Lakes Indian Fish and Wildlife Commission (Amnicon, Middle, Bad, Firesteel, Misery, Traverse, Silver, and Huron rivers) and the Wisconsin Department of Natural Resources (Brule River).

The total number of spawning-phase sea lampreys was estimated in U.S. waters of Lake Superior for the third consecutive year. The estimate, based on a significant relation of average stream discharge (x) and the number of adult lampreys that enter tributaries (y), was calculated separately for streams east and west of Keweenaw Bay. In waters west of Keweenaw Bay, an estimated 36,611 ($y=19.62x$; $P<0.01$, $r=0.84$) were present, while 6,259 ($y=3.10x$; $P<0.01$, $r=0.67$) lampreys were estimated east of Keweenaw Bay. The total estimate of 42,870 sea lampreys in 1988 was calculated using a combined flow of 3,887 ft^3/s (1,866 west and 2,021 east) and compares with 23,166 sea lampreys estimated in 1987.

As a recommendation of the Sterile Male Release Technique Task Force, 2,250 normal, marked male sea lampreys were introduced directly into three Lake Superior tributaries in 1988. The Iron, Silver, and Tahquamenon rivers were selected as study streams because each possess a relatively stable number of spawning-phase sea lampreys, an in-stream barrier to lampreys, high water quality, and visible, well-defined spawning areas. The study tested the effects of time (stage of spawning-run), location, and method of release (acclimation period) on the movement and behavior of spawning-phase sea lampreys.

Male sea lampreys released into the tributaries were taken from assessment traps in the Cheboygan (Lake Huron) and Manistique (Lake Michigan) rivers during the early, peak, and late stages of the spawning migration. For each of these groups, lampreys were released at three different locations in the rivers (mouth, midpoint, and barrier) and at each location, by two different methods (immediate release and caged in-stream for 48 hours). The movement and behavior of the marked lampreys in the rivers were monitored by searching spawning areas and with assessment traps.

The results showed that in-stream releases of male sea lampreys can be an effective method of release in a sterile male program. Time of release (stages of the spawning run) did not affect dispersal or behavior if the males were not held in warm water for an extended period of time before release. The location of release had no effect on the rate of recovery in the Tahquamenon River, but the rate was lower for lampreys released at the mouths of the Iron and Silver rivers than those released at the midpoints and barriers.

Table 5. Number and biological characteristics of adult sea lampreys captur
in assessment traps in tributaries of Lake Superior, 1988.

[Letter in parentheses corresponds to location of stream in Figure 1.]

Stream	Number captured	Number sampled	Percent males	Mean length(mm)		Mean weight (	
				Males	Females	Males	Female
UNITED STATES							
Tahquamenon River (A)	273	2	0	-	450	-	211
Betsy River (B)	52	2	50	514	365	272	118
Sucker River (C)	0	-	-	-	-	-	-
Miners River (D)	10	4	50	366	374	118	164
Rock River (E)	515	243	42	436	430	192	182
Big Garlic River (F)	9	2	0	-	433	-	218
Iron River (G)	3	0	-	-	-	-	-
Huron River (H)	51	24	33	461	458	219	221
Silver River (I)	0	-	-	-	-	-	-
Traverse River (J)	11	3	33	452	457	208	180
Misery River (K)	261	211	22	364	407	175	229
Firesteel River (L)	17	13	8	450	418	251	272
Bad River (M)	972	352	29	437	434	178	178
Brule River (N)	1,260	93	55	454	459	212	213
Middle River (O)	11	0	-	-	-	-	-
Amnicon River (P)	14	0	-	-	-	-	-
Total or average	3,459	949	33	429	428	189	197
CANADA							
Neebing-McIntyre Floodway (Q)	72	0	-	-	-	-	-
Wolf River (R)	283	0	-	-	-	-	-
Pancake River (S)	77	75	39	432	431	179	195
Carp River (T)	110	107	44	431	441	189	197
Stokeley Creek (U)	17	16	56	445	458	187	226
Total or average	559	198	43	433	438	185	198
GRAND TOTAL or average	4,018	1,147	35	430	430	188	197

Strong lake seiches were observed at the mouths of both streams and the lampreys may have migrated into Lake Superior. An overnight period of acclimation proved unnecessary in all rivers. This study was conducted in cooperation with the Hammond Bay Biological Station and a detailed report of the results is included in the annual report of that station to the Great Lakes Fishery Commission.

Canada

A total of 559 adult sea lampreys were captured in assessment traps on 5 tributaries in 1988 (Fig. 1), compared to 181 from those same streams in 1987. Biological information collected from three streams is listed in Table 5 (specimens from the other two streams were used in mark-recovery work to estimate trap effectiveness). This was the first year of operation for the new trap built into the modified fishway on the McIntyre River (part of the Neebing-McIntyre Floodway) at Lakehead University. Only five adults were captured in the built-in trap, compared to one captured by a portable trap at this site in 1987. A portable trap at a low-head dam on the Neebing portion captured 67 adults.

This was the first year the new low-head barrier and built-in trap on the Wolf River was operated. The adult catch increased to 283 from 34 captured in 1987 by portable traps at the same site. Trap effectiveness estimates based on mark-recovery were 52 percent on the Wolf River and 7 percent on the Neebing River. Population estimates derived from the same studies were 547 for the Wolf River and 507 for the Neebing River.

The six low-head barrier dams, which incorporated built-in adult traps were maintained as required in 1988.

PARASITIC-PHASE ASSESSMENTS

United States

A total of 304 sea lampreys were collected from commercial fishermen in Lake Superior through October 1988 (Table 6), compared with 473 taken in 1987. More sea lampreys were collected from fishermen in statistical district MS-4 (Munising, Michigan, area) than from any other district, but the number dropped from that taken in 1987 (241 in 1987 vs. 104 in 1988).

Parasitic-phase sea lampreys are collected throughout the year from commercial fishermen; therefore, lampreys that would spawn in either the present or succeeding two years may be found in the catch. Spawning year was determined for the 304 parasitic-phase sea lampreys captured in 1988 (167 would have spawned in 1988 and 137 in 1989). The 1988 spawning year classes taken in 1987 yielded 106 lamprey, bringing the total collected for that spawning year to 273, and represents a decrease in the number of parasitic-phase sea lampreys captured by commercial fishermen (431 of 1987 spawning year vs. 273 of the 1988 spawning year).

Sport anglers in Lake Superior captured 75 parasitic-phase sea lampreys in 1988 (Table 6), compared with 63 in 1986 and 58 in 1987. Charterboat captains returned 20 parasitic-phase lampreys and non-charter fishermen returned 55.

Occurrence of sea lampreys and lamprey wounds were reported by 4 charterboat captains. The operators reported 0.2 lampreys attached per 100 lak trout (Table 7), and 80% of the lampreys they collected had been attached to lak trout. The data from the charter operators in Michigan and Wisconsin were received through cooperative agreement with the Departments of Natural Resources

LAKE MICHIGAN

LARVAL ASSESSMENT

United States

A total of 101 Lake Michigan tributaries and eight offshore areas were surveyed in 1988. Sea lampreys reestablished in 52 streams, and larvae from the 1988 year class were present in 25. Reestablishment surveys indicated no evidence of recruitment in 28 streams since their last chemical treatment. Pretreatment investigations were conducted on 30 streams, 14 were treated in 1988 and 16 are scheduled for treatment in 1989.

Surveys were completed on 14 streams to evaluate the effectiveness of recent treatments. A moderate number of residual larvae were recovered from the lower Black River (Mackinac County). Small numbers of larvae were recovered in the Boardman, Boyne, and Jordan rivers and Mann (a tributary to the Kalamazoo River) and Hog Island creeks.

Drought conditions in 1987-88 may have affected the larval lamprey population in some streams. Surveys on the Oconto River in June, 1988 recovered 115 sea lampreys and 242 Ichthyomyzon spp. Subsequent surveys in September, after prolonged drought, yielded only 2 sea lampreys and 15 Ichthyomyzon spp. Hibbards Creek has a history of annual recruitment of larvae, but the past two-year classes are absent.

Surveys were conducted on Haymeadow Creek (Whitefish River) to evaluate the effectiveness of an experimental electric barrier operated during 1987-88 by the Michigan Department of Natural Resources. A total of 426 sea lamprey larvae, including 38 from the 1988 year class were recovered from 4 locations above the barrier. The presence of the 1987 and 1988 year classes indicate the barrier was not operated as early as necessary to stop migrating adult lampreys, or was ineffective for some other reason during the operational period.

Table 6. Number of parasitic-phase sea lampreys collected in commercial and sport fisheries in U.S. waters of the Upper Great Lakes in 1988.

Lake Superior				Lake Michigan				Lake Huron				
District	Spawning year[a] Commercial 1988	Commercial 1989	Sport 1989	District	Spawning year[a] Commercial 1988	Commercial 1989	Sport 1989	District	Spawning year[a] Commercial 1988	Commercial 1989	Commercial 1990	Sport 1988
M-1	-	-	9	MM-1	32	35	-	MH-1	76	762	5	555
M-2	0	0	1	MM-2	2	0	-	MH-2	2	65	0	804
M-3	1	2	0	MM-3	12	13	4	MH-3	-	-	-	500
Wis.	42	27	10	MM-4	1	1	4	MH-4	173	112	0	438
MS-1	-	-	-	MM-5	2	0	21	MH-5	-	-	-	170
MS-2	-	-	17	MM-6	-	-	62	MH-6	-	-	-	59
MS-3	51	12	4	MM-7	0	80	14					
MS-4	32	72	33	MM-8	-	-	2					
MS-5	40	7	1	WM-1	0	0	20					
MS-6	1	17	-	WM-2	9	20	13					
				WM-3	2	15	25					
				WM-4	48	8	108					
				WM-5	-	-	61					
				WM-6	-	-	6					
				Ill.	-	-	4					
				Ind.	-	-	7					
Total	167	137	75		108	172	351		251	939	5	2,526

[a]Parasitic sea lampreys are collected throughout the year from commercial fishermen; therefore, lampreys that would spawn in either the present or succeeding years may be found in the catch. Those lampreys taken in the sport fishery are collected primarily in the summer when only lampreys that would spawn the following year are present.

Table 7. Incidence of sea lampreys, and numbers of lake trout and chinook salmon[a] taken by captains in the charter boat fishery, 1988.

[Incidence of sea lampreys is the number of lampreys attached per 100 fish; includes lampreys that were brought in the boat and those that were observed but dropped off the fish.]

Lake and district[b]	Incidence on lake trout		Incidence on chinook salmon	
	Sea lampreys per 100 trout	Number of trout	Sea lampreys per 100 salmon	Number of salmon
Superior				
Wis.	0.2	4,617	0.0	498
Michigan				
WM-1	-	9	0.8	264
WM-2	0.0	12	0.2	2,700
WM-3	0.1	2,570	0.1	6,962
WM-4	0.02	11,582	0.1	9,403
WM-5	0.1	6,295	0.1	11,398
WM-6	0.02	8,196	0.0	1,190
Ill.	0.3	747	0.0	149
All districts	0.1	29,411	0.2	32,066

[a]Lake trout and chinook salmon are the primary target species of the charter fishery of the Upper Great Lakes.

[b]Data were not obtained or have not been evaluated from districts M-1 to M-3, MS-1 to MS-6, MM-1 to MM-8, Ind., and MH-1 to MH-6.

Lentic surveys were conducted in eight offshore areas. In Lake Charlevoix, 1,884 larvae (36-178 mm) were found near the mouth of the Boyne River and 96 larvae (45-175 mm) near the mouth of Porter Creek. A total of 170 larvae (22-173 mm) were recovered in Petoskey harbor near Bear River and 19 larvae (45-126 mm) offshore of the Days River. Chemical treatments are recommended annually on the Boyne River and Porter Creek to reduce the larval recruitment to the lentic areas. No sea lampreys were found offshore of Wycamp Lake Outlet, and the Rapid, Whitefish, and Oconto rivers.

Surveys were conducted on five streams to evaluate the efficiency of dams to stop upstream migration of spawning-run lampreys. Small numbers of larvae were recovered above the dams on the White and Boardman rivers, but no larvae were recovered above dams on the Betsie, St. Joseph, and East Twin rivers.

Larval sea lampreys have populated the upper Paw Paw River (tributary to St. Joseph River) since stopboards on the dam at Watervliet, Michigan, were removed in 1982. The river appears to be a major producer of larval lampreys in southern Lake Michigan, and the number of miles of river infested with lampreys has increased from 33 before the barrier was removed to a present 95. Collections during the lampricide treatment in 1988 included 960 sea lamprey larvae and 99 transformers. Cost of this treatment has more than doubled and we recommend replacement of the barrier.

CHEMICAL TREATMENTS

United States

Chemical treatments were completed on 22 streams (Table 8, Fig. 2) with a combined discharge of 61.2 m^3/s (2,157 f^3/s). Larval abundance was high in Mann Creek, Boyne River, Elk Lake Outlet, and the Jordan River, and medium to low in the other treated streams. Record low water levels caused schedule disruptions, user conflicts with irrigators, and some treatment postponements. The St. Joseph River system which includes Blue and Pipestone creeks and the Paw Paw River required five separate treatments. The Manistique River treatment was rescheduled due to low flows and later postponed until 1989 due to high flows. Swan, Valentine, and Sunny Brook creeks were postponed until 1989 because of priority to other treatments. The Brevort River was postponed because of low water flow.

Fish mortality was low during most of the stream treatments. A moderate kill of small nongame fish occurred in a section of a Paw Paw River tributary, and several hundred spawning suckers were killed during treatment of the Millecoquins River. Some mayfly mortality occurred in the lower Jordan and upper Paw Paw rivers.

The effects of pH, dissolved oxygen, and water temperature on static toxicity test results remain in question. Toxicity tests were conducted on ten streams and some of the acute static tests conducted on streams in the lower peninsula of Michigan produced significantly higher minimum lethal concentrations (MLCs) than those indicated by the prediction chart.

Table 8. Details on the application of lampricides to streams of Lake Michigan, 1988

[Number in parentheses corresponds to location of stream in Figure 2. Lampricides used are in kilograms/pounds of active ingredient.]

Stream	Date	Discharge m^3/s	Discharge f^3/s	TFM[a] kg	TFM[a] lbs	Bayer 73 powder kg	Bayer 73 powder lbs	Stream treated km	Stream treated miles
Ford R. (4)									
Ten Mile Cr.	May 1	1.6	55	377	831	-	-	37.1	23
Cedar R. (3)	May 2	2.8	100	419	924	-	-	37.1	23
Millecoquins R. (10)									
Furlong Cr.	May 13	0.5	18	131	289	-	-	11.3	7
Mainstream	May 15	3.7	130	579	1,276	-	-	16.1	10
Peshtigo R. (1)	June 10	9.2	325	2,455	5,412	-	-	16.1	10
Trail Cr. (21)	June 11	1.0	35	206	455	-	-	12.9	8
Beattie Cr. (2)	June 13	<0.1	1	11	24	-	-	1.6	1
Burns Ditch (22)									
Kemper Ditch	June 14	0.5	17	133	293	-	-	6.5	4
St. Joseph R. (20)									
Blue Cr.	June 22	0.5	18	132	290	-	-	9.7	6
Pipestone Cr.	June 29	0.4	13	185	408	-	-	8.1	5
Paw Paw River	July 10	6.3	224	2,189	4,825	5.6	12.4	129.0	80
Kalamazoo R. (19)									
Mann Cr.	June 30	0.1	4	23	50	-	-	1.6	1
Porter Cr. (15)	July 22	0.2	7	50	110	-	-	1.6	1
Boyne R. (14)	July 22	1.7	60	489	1,078	-	-	9.7	6
Horton Cr. (13)	July 24	0.4	14	100	220	-	-	1.6	1
Platte R. (18)									
Middle Platte R.	Aug. 5	3.5	125	728	1,606	-	-	1.6	1
Upper Platte R.	Aug. 9	3.3	115	661	1,457	-	-	16.1	10
Elk Lake Outlet (17)									
North Channel	Aug. 9	7.6	268	1,188	2,618	-	-	1.6	1
Jordan R. (16)	Aug. 19	4.7	165	1,350	2,976	5.7	12.6	37.1	23
Marblehead Cr. (8)	Aug. 20	0.2	7	30	66	-	-	1.6	1
Gulliver Lake Outlet (9)	Aug. 22	<0.1	1	10	22	-	-	1.6	1
Wycamp Lake Outlet (12)	Sept. 21	0.7	26	149	328	-	-	3.2	2
Carp Lake R. (11)	Sept. 21	0.1	4	46	101	-	-	3.2	2
Tacoosh R. (5)	Oct. 14	1.1	40	167	368	-	-	9.7	6
Ogontz R. (7)	Oct. 15	1.0	35	113	250	-	-	19.4	12
Rapid R. (6)	Oct. 18	9.9	350	1,331	2,934	-	-	32.3	20
Total		61.2	2,157	13,252	29,211	11.3	25.0	427.4	265

We further studied this inconsistency, and preliminary results indicate that higher pH levels in aerated vs. unaerated vessels may have been the cause of the problem. The toxicity of TFM to sea lampreys was greater in the unaerated test at the lower pH and compared closely to results of a flow-through bioassay test performed concurrently. Unaerated static tests or flow-through tests may produce more consistent results in hard water streams than the aerated, static test procedures used in the past.

A toxicity test was completed in conjunction with the treatment of the Millecoquins River (Mackinac Co., Michigan). The purpose was to delineate the effects of pH changes on TFM toxicity to sea lampreys and several nontarget species. Treated Millecoquins River water was pumped through a flow-through test unit where pH values of the water were altered to compare results. Test animals also were caged in the stream. The lampricide TFM appears more toxic at lower pH values. Mortality among target and nontarget species was 100% in water in which pH was lowered 1.0 unit. In the stream at ambient pH, sea lamprey mortality was 100% with no nontarget mortality. Mortality of sea lampreys was 55% with no nontarget mortality in water in which the pH was raised by 1.0 unit.

Naturally occurring diurnal changes of pH have been noted in some stream treatments. These occurrences may have contributed to nontarget mortality or to survival of sea lampreys during past chemical treatments. Further tests will be conducted at the Hammond Bay Biological Station to determine the toxicity of lampricide to target and nontarget animals within a range of alkalinities at selected pH levels. The objective will be to develop a prediction chart which will help treatment supervisors cope with fluctuations in pH levels.

SPAWNING-PHASE ASSESSMENT

United States

A total of 16,776 sea lampreys were captured in assessment traps placed in 6 west shore and 5 east shore tributaries of Lake Michigan in 1988 (Table 9, Fig. 2), compared to 9,635 in 1987. The average length and weight of lampreys sampled from Lake Michigan tributaries in 1988 increased slightly over those taken in 1987. The percentage males remained about the same.

Along the west shore, the catch of sea lampreys in the Manistique River increased significantly over the number taken in 1987 (7,668 vs. 15,223). The increase is due to the first year placement and operation of a mechanical weir with trap (greatly increased holding capacity of lampreys compared to past years) built into the floor of the stream. Although the trap catch increased, a stratified mark and recovery system (used for the fifth consecutive year) to estimate the number of spawning-phase sea lampreys in the river, indicated a smaller spawning population in the river than in 1987 (29,416 vs. 20,293) and demonstrates the resultant increased trap efficiency. As a comparison to 1987, the total catch of lampreys in the other five streams along the west shore declined by 28% (from 992 to 719). The catch of lampreys increased in the Peshtigo River and decreased in the Menominee and Ford rivers; the latter likely due to reduced effort and initially high water levels. Traps in the East Twin River captured about the same number as in 1987 and no sea lampreys were captured in the Fox River for the tenth consecutive year, although efforts increased substantially from that in 1987.

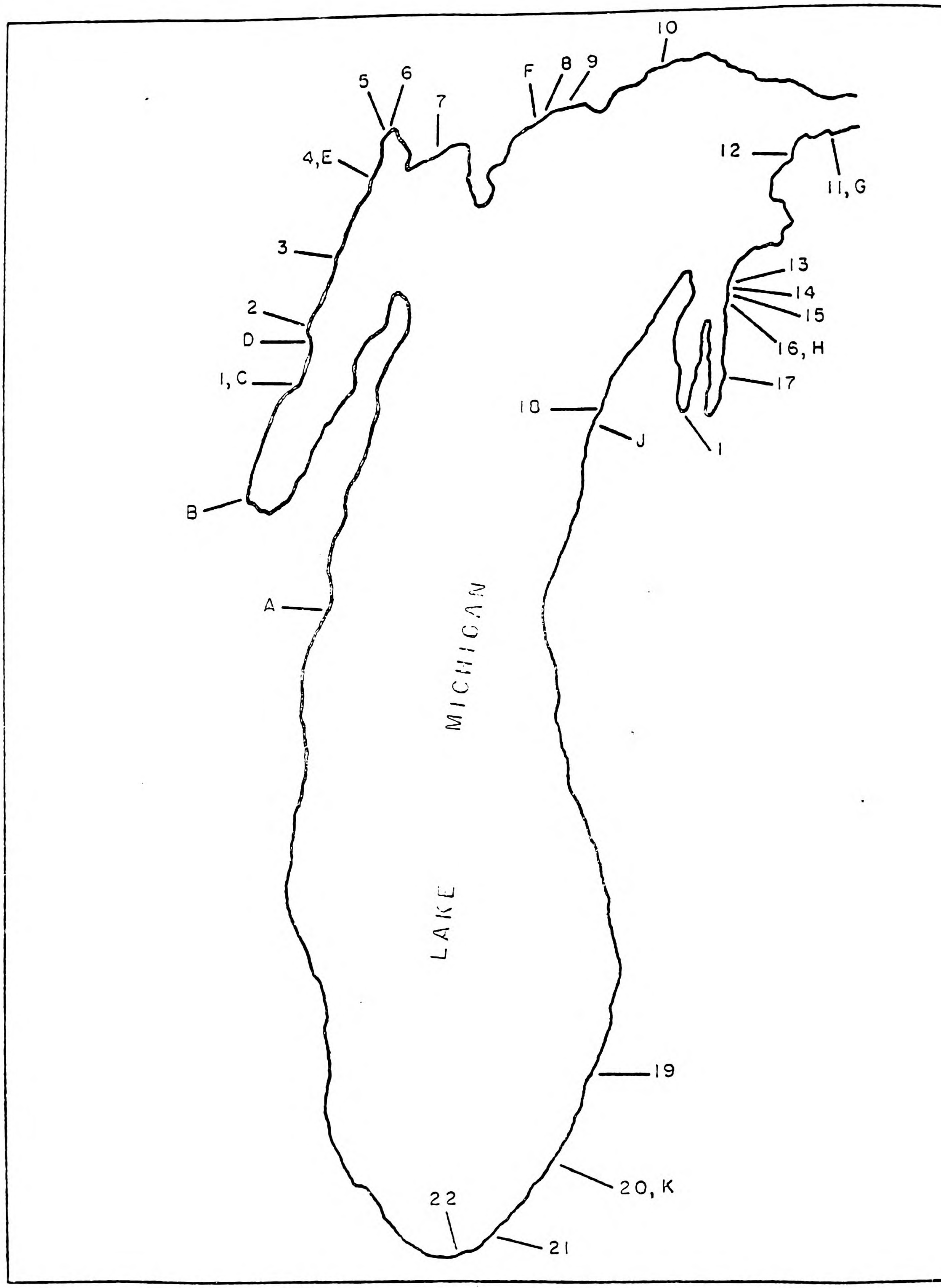

Figure 2. Location of Lake Michigan tributaries treated with lampricid
(numerals; see Table 8 for names of streams), and of streams where
assessment traps were fished (letters; see Table 9 for names of stream
in 1988.

The total catch of sea lampreys in streams along the east shore of Lake Michigan decreased slightly from 1987 (975 vs. 834). Trap catches increased in the Carp Lake and Betsie rivers and decreased in Deer Creek and the St. Joseph and Boardman rivers. The decline in the Boardman River may be attributed to the construction of a fish passage structure that has altered the trapping characteristics of that site.

In cooperation with the Wisconsin Department of Natural Resources, attempts to capture spawning-phase sea lampreys near the De Pere dam on the Fox River were intensified in 1988. A total of 12 hoop-fyke nets and three assessment traps were set in several locations downstream of the dam. In addition, backpack electrofishing gear was used in the shallow rocky areas downstream of the south spillway section of the dam. No adult sea lampreys were captured. Following the review and recommendations of a State of Wisconsin legislative committee, the lock at Kaukauna, Wisconsin, was dewatered and sealed, and the adjoining dam and floodgates were modified to form a barrier to migrant sea lampreys.

PARASITIC-PHASE ASSESSMENT

United States

Lake Michigan commercial fishermen captured 280 sea lampreys through October 1988 (Table 6), compared with 338 in the same period in 1987. Of the total, 184 were collected from northern Lake Michigan and 96 from Green Bay, compared with 174 and 164, respectively in 1987.

Table 9. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Michigan, 1988. [Letter in parentheses corresponds to location of stream in Figure 2.]

Stream	Number captured	Number sampled	Percent males	Mean length (mm) Males	Mean length (mm) Females	Mean weight (g) Males	Mean weight (g) Females
West Shore							
East Twin River (A)	16	13	38	451	414	188	239
Fox River (B)	0	-	-	-	-	-	-
Peshtigo River (C)	580	556	42	506	507	266	283
Menominee River (D)	90	90	49	497	503	258	287
Ford River (E)	33	0	-	-	-	-	-
Manistique River (F)	15,223	693	39	497	500	268	289
East Shore							
Carp Lake River (G)	378	264	38	469	474	222	240
Jordan River (H)							
Deer Creek	15	15	27	532	502	315	284
Boardman River (I)	35	34	35	461	484	233	257
Betsie River (J)	251	233	38	487	479	255	253
St. Joseph River (K)	155	153	39	500	502	294	292
Total or average	16,776	2,051	40	494	495	261	276

Spawning year was determined for the 280 parasitic-phase sea lampreys; 10 would have spawned in 1988, and 172 in 1989. In addition, 220 lampreys of th 1988 spawning year were taken in 1987, bringing the total collected for thi spawning year to 328. This represents a slight increase in the number o parasitic-phase sea lampreys captured by commercial fishermen (293 of the 198 spawning year vs. 328 of the 1988 spawning year).

A total of 351 sea lampreys were gathered from the Lake Michiga sportfishery, 96 from charter and 255 from noncharter fishermen (Table 6) compared with 666 in 1987 (charter; 253 and noncharter; 413). (At this time we cannot compare catch rates in the charter fishery between 1987 and 198 because the data is incomplete from State of Michigan waters.) Most of th lampreys were recovered from statistical districts WM-4 and WM-5 (Algoma t Milwaukee in Wisconsin), and MM-6 (Arcadia to Little Sable Point in Michigan) and were captured during July to September. Occurrence of sea lampreys on fis was reported by 499 charterboat captains (Table 7). Lakewide, 71% of th lampreys collected were attached to chinook salmon, compared with 81% in 1987 The number of lampreys per 100 lake trout remained the same as for 1987 (0.1) while the number/100 chinook decreased from 0.3 in 1987 to 0.2 in 1988 (Table 7). Incidence rates were derived from data collected in Wisconsin Illinois, and Indiana waters.

LAKE HURON

LARVAL ASSESSMENT

United States

Forty-six Lake Huron tributaries were examined for reestablished an residual sea lamprey populations. Survey crews searched for newly-infeste streams and laid the ground work for chemical treatments. Pretreatmen investigations were completed on 15 streams; eight were treated in 1988 and th others are scheduled for treatment in 1989. Sea lamprey populations ha reestablished in 34 streams, and young-of-the-year larvae were found in 1 streams. Abundant numbers of larvae were present in the Pine (Mackinac County Michigan), Carp, Cheboygan, and Rifle rivers and smaller populations in th others. Posttreatment surveys were conducted in 11 streams. Residual se lampreys were found in the Ocqueoc and Big Salt rivers and Albany, Hessel Elliot, Green, Mulligan, Black Mallard, and Schmidt creeks. None of the residua populations are of a size sufficient to warrant remedial action.

Sea lampreys were recovered in one of two offshore areas examined wit granular Bayer 73. Twenty larvae (63-141 mm) were collected from 6,131 m (66,000 ft^2) at the outlet of the Sturgeon River in Burt Lake. No lampreys wer found offshore of the East Au Gres River.

Young-of-the-year sea lampreys were found upstream of the barrier on Alba Creek in 1988. Spawning-phase sea lampreys were able to bypass the barri through either a gap created by a malfunction during raising and lowering of th hinged plate or undercut footing of the dam.

Surveys continued in 1988 to monitor populations of larval sea lampreys in the St. Marys River. A total of 23 index locations of 0.2 ha (0.5 acre) each were surveyed with Bayer 73 granules and 952 larval and 13 transforming sea lampreys were collected. In addition, four studies were initiated and one study continued in 1988 to fill information gaps on sea lamprey populations in the river. The new studies are designed to measure larval growth rates, establish rates of metamorphosis, estimate downstream migration of young parasitic-phase lampreys, and evaluate new sampling techniques.

On September 20, a side channel of the St. Marys River, near the Little Rapids Cut, was surveyed with TFM to assess the sea lamprey population and provide corroborating data for future studies. The side channel was 2.4 km (1.5 miles) in length, about 60.7 ha (150 acres) in surface area, and 62.3 m^3/sec.(2,200 ft^3/sec.) in water flow. A mark-recapture population estimate of sea lampreys was conducted in conjunction with the chemical survey. Total estimated sea lampreys in the surveyed area were 255,000, and included 244,000 larvae and 11,000 transforming larvae. The estimate of transforming larvae is probably conservative because of competition with sea gulls eating sea lampreys during the survey.

In addition to the mark and recapture techniques used to estimate the larval sea lamprey population in the Little Rapids Cut area, SCUBA divers and a dredge were used to collect and estimate the number of larvae in a 54,000 m^2 (581,270 ft^2) portion of the channel prior to the chemical survey (Fig. 3). A Treasure Emporium gold dredge, operated by divers, sampled 215-1 m^2 randomly selected plots on the stream bottom (0.4% of the total study area). Each plot was excavated to a depth of 20 cm (7.9 inches) and the samples were examined for the presence of sea lampreys. Mean density of sea lampreys in the study area was 1.5/m^2 and an estimated 78,193 lampreys (75,847 larvae and 2,346 transforming larvae) were present. At the time of the chemical survey, 79,553 lampreys (76,371 larvae and 3,182 transforming larvae) were estimated for the same area by mark and recapture techniques.

A larval growth and transformation study was initiated in 1988. Eighteen metal cages (1 x 1 x 0.5 m) were used for the study. In May, 360 (age 0) sea lamprey larvae and 180 larvae >116 mm were collected from the St. Marys River by electrofishing. The larvae were measured and placed in the cages with suitable habitat at a density of 30 larvae/m^2. The cages were placed at two locations in the river, a side-channel near the Little Rapids Cut, and Nine-Mile Point in Lake Nicolet (Fig. 4). Six cages of age 0 larvae and 3 cages of larvae >116 mm were placed at each location. In September the cages were raised, the larvae measured, transformers were removed, and the cages and remaining larvae returned to the river. This procedure will be repeated annually until the time of transformation of the age 0 larvae is determined. Mortality averaged 47% for the age 0 larvae and 6% for larvae >116 mm during the initial five months of the study. A total of 72 of 170 larvae >116 mm metamorphosed (42% average transformation rate).

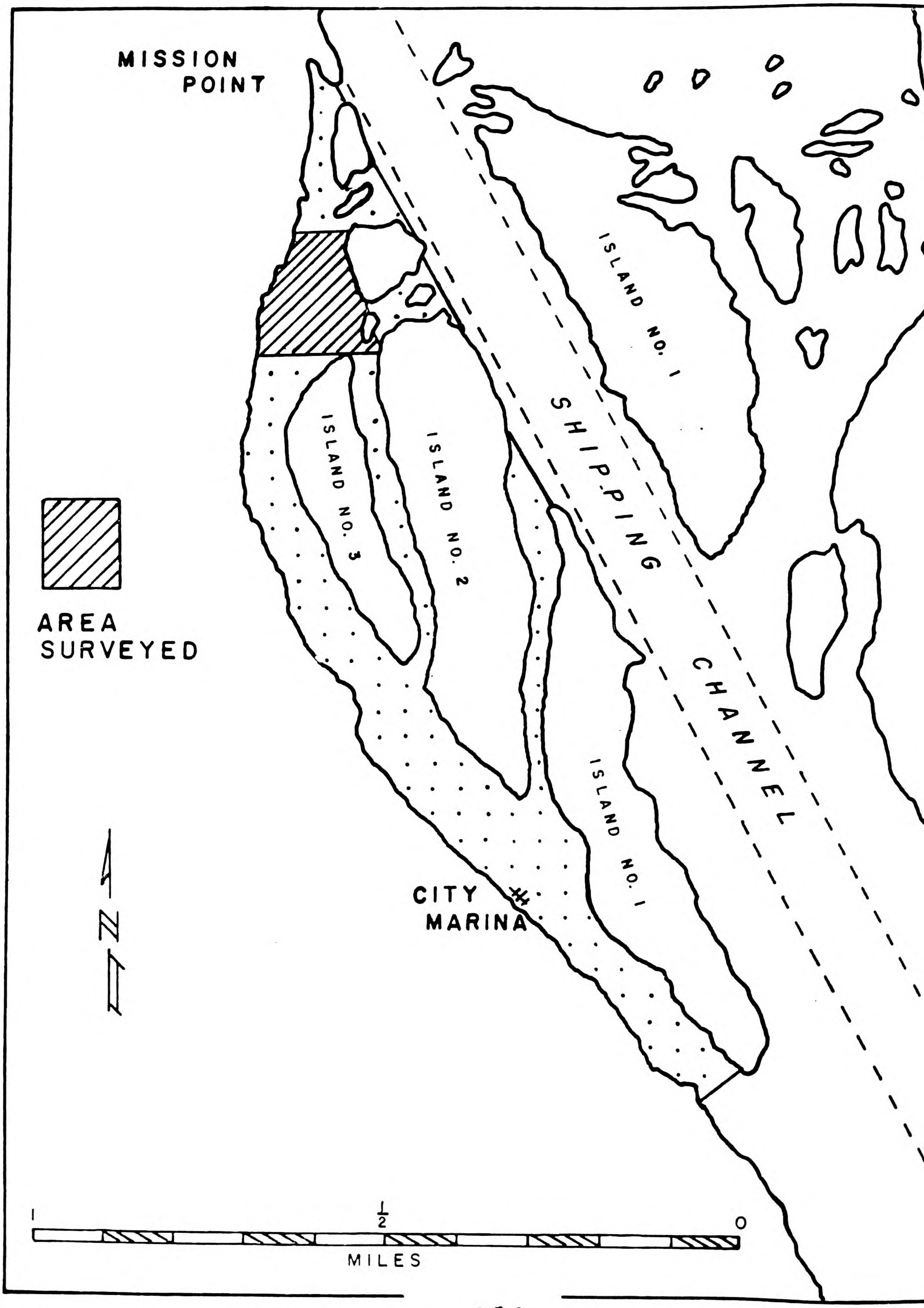

Figure 3. Area in the Little Rapi he St. Marys River where a suc
dredge was used to esti lation of larval sea lampreys.

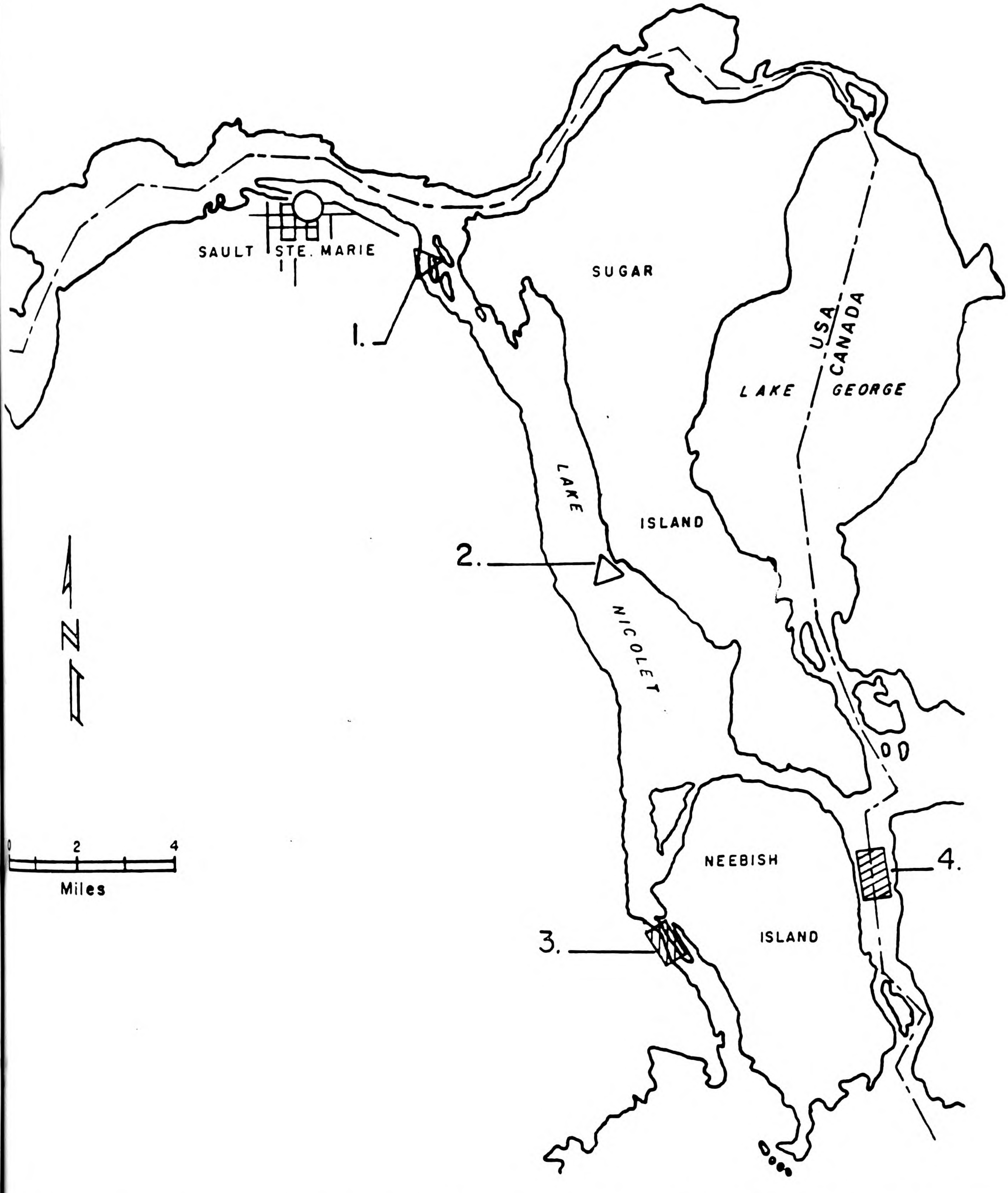

Figure 4. Locations in the St. Marys River where cages with sea lamprey larvae were set at Little Rapids Cut (1) and Nine Mile Point (2) for studies of growth and transformation; and, where trawling for newly-transformed sea lampreys was conducted at West Neebish (3) and Munuscong (4) channels in 1988.

A fyke netting operation continued in the spring and fall of 1988 t capture emigrating young parasitic-phase lampreys in the river. Nets wer installed on April 16 at the same locations and fished in the same manner a during the fall of 1987 when 11,500 net hours yielded 65 lampreys. No lamprey were caught in the spring.

The fall netting operation commenced on October 27 and continued throug November 28. The nets were fished in the West Neebish (5 locations), Middl Neebish (9 locations), and Munuscong (12 locations) channels, and 150 lamprey were netted from 23 of 26 locations. Nets fished at these same locations in 198 captured 24 lampreys. After compensating for differences in net sizes and hour fished, the 1988 catch rate (lampreys/hour) was almost twice the rate in 1987

The Marquette and Hammond Bay Biological Stations trawled for youn parasitic-phase sea lampreys during the fall downstream migration period on th St. Marys River. The initial objective was to quantify the number of lamprey migrating through the West Neebish and Munuscong channels (Fig. 4). Th objective was changed to an evaluation of feasibility and technique, because o the need for more training of personnel, and an earlier than expected migrator period of lampreys in 1988. A total of 42 young parasitic-phase lampreys wer caught in 59 tows for an average of 0.7 lampreys/tow. Trawling proved capabl of sampling the number of downstream migrants in the St. Marys River, and wil better quantify total numbers than sampling with fyke nets. The Hammond Ba Biological Station has written a detailed report on the study.

Canada

Larval surveys conducted on 83 Lake Huron tributaries monitored rees tablished, residual and untreated populations, searched for new infestations and prepared for 1989 chemical treatments.

Distribution surveys were completed on 13 streams recommended for treatmen in 1989. Sea lampreys were found in the main branch of the Two Tree River, whic has not been treated since 1972.

Treatment evaluation and reestablishment surveys on four streams (Root Garden, Echo and Mississagi rivers) treated in 1987 found low numbers of residua lamprey in all the streams. All but the Root River have reestablished with th 1987 year class.

Routine surveys of 52 streams with the apparent potential for sea lampre production, but no history of doing so, led to the discovery of two ne producers. They are Timber Bay Creek and Beaver River. Large numbers of larva including those of transformable size were collected in Timber Bay Creek, a smal Manitoulin Island stream. This discovery prompted the addition of this strea to the 1988 treatment schedule, but was rescheduled due to low stream flows A single sea lamprey larva was collected from Beaver River (a tributary t Georgian Bay). Sea lamprey larvae were collected from the Kagawong River o Manitoulin Island, a first in the stream proper. A delta population has bee present for many years.

The St. Marys River sea lamprey population was surveyed with granular Bayer on 29 index plots in Canadian waters. Seventeen of these index stations (2000 m^2 each) were duplicates of those done in 1986. The respective total catches of 431 sea lamprey larvae in 1988, compares to 801 in 1986. The apparent decrease in larval abundance may be a reflection of the change in granular Bayer application rates to 5.6 kg active incredient/ha (12.3 lbs/acre) in 1988, from the norm of 11.2 kg active incredient/ha (24.7 lbs/acre) in earlier years. Surveys of the Spanish River in the North Channel, which recovered 593 larvae, indicate a large and well distributed larvae sea lamprey population. The entire river was treated in 1972, and has shown a gradual improvement in larval habitat because of clean-up efforts by the Espanola paper mill during the last 20 years. A full scale lampricide treatment is scheduled for the Spanish River in 1989.

CHEMICAL TREATMENT

United States

Chemical treatments were completed on eight streams (Table 10, Fig. 5) with a combined discharge of 22.6 m^3/s (796 f^3/s). Low flows caused problems during three treatments and delayed two others. The Pine (St. Clair River) and Little Pigeon rivers had to be treated by sections to insure timely progress and only the upper portion of Albany Creek could be treated. The Charlotte River and Sweiger Creek (Pine River) had to be postponed until 1989.

Three tributaries to the Saginaw River system (Pine River and Carroll and Big Salt creeks) recently became infested with sea lampreys as a result of modifications made to the Dow Company Dam at Midland, Michigan. The treatments of Carroll and Big Salt creeks had been postponed in 1987 because of low water levels, but were successfully treated in May 1988. The Pine River treatment originally was scheduled for May but was postponed because the diurnal fluctuation in dissolved oxygen ranged from 49% to over 151% saturation. The fluctuation was not exaggerated in the fall, and the treatment was successfully conducted in October. The pH and dissolved oxygen levels in the river were monitored throughout the treatment and pH lowered when TFM was present in the water.

Abundance of sea lamprey larvae was moderate in Albany, Silver and Ceville creeks, and in the Ocqueoc and Little Pigeon rivers, and low in the other streams. The sea lamprey population was small in the Pine River (Saginaw River), and many of the larvae were transforming. Distribution of the larvae was farther upstream than expected in the Pine (St. Clair River) and Little Pigeon rivers.

Mortality of nontarget fishes occurred in several treatments. Spawning suckers were killed during treatment of the Pine River (St. Clair River) in early May. Moderate mortality of several species of nongame fishes occurred in the upper reaches of the Pine River and Big Salt Creek. The nontarget mortality may have been a result of fluctuations of pH and dissolved oxygen. Spawning brown trout were reported dead in large numbers in Club Creek (Sturgeon River), but examination of the entire stream revealed 10 dead trout.

Table 10. **Details on the application of lampricides to streams of Lake Huron, 1**
[Number in parentheses corresponds to location of stream in Figure 5.
Lampricides used are in kilograms/pounds of active ingredient.]

Stream	Date	Discharge m³/s	Discharge f³/s	TFM[a] kg	TFM[a] lbs	Bayer 73 Powder kg	Bayer 73 Powder lbs	St tr km
UNITED STATES								
Pine R. (9)	Apr. 30	1.4	50	519	1,144	-	-	25.8
Saginaw R. (10)								
Carroll Cr.	May 11	0.8	27	108	238	-	-	3.2
Big Salt Cr.	May 11	1.0	35	429	946	-	-	9.7
Pine R.	Oct. 30	6.8	240	3,842	8,470	-	-	51.6
Albany Cr. (16)	May 18	0.2	6	22	48	-	-	4.8
Tawas R. (11)								
Silver Cr.	July 23	0.7	26	84	185	1.6	3.5	8.1
Ocqueoc R. (12)	Sept. 29	3.2	114	1,107	2,440	-	-	35.5
Nunns Cr. (15)	Oct. 13	0.5	17	183	403	-	-	3.2
Cheboygan R. (13)								
Little Pigeon R.	Oct. 14	0.1	4	83	183	-	-	4.8
Sturgeon R.	Oct. 17	7.8	275	2,327	5,130	-	-	45.2
Ceville Cr. (14)	Oct. 15	0.1	2	14	31	-	-	1.6
Total		22.6	796	8,718	19,218	1.6	3.5	193.5
CANADA								
Gordon Cr. (1)	May 31	0.1	1	5	11	-	-	1.2
Still R. (5)	June 2	1.4	50	72	159	-	-	19.7
Thessalon R. (3)	June 6	6.3	222	433	955	3.3	7.3	29.3
Naiscoot R. (7)	June 6	2.2	77	101	223	-	-	10.5
Magnetawan R. (6)	June 10	16.0	564	898	1,980	-	-	6.5
Spanish R.								
Aux Sables R. (4)	June 16	10.0	361	281	619	-	-	2.1
Musquash R. (8)	Aug. 24	8.5	301	739	1,629	-	-	3.2
Browns Cr. (2)	Aug. 30	0.1	1	10	22	-	-	2.9
Total		44.8	1,577	2,539	5,598	3.3	7.3	75.4
GRAND TOTALS		67.3	2,373	11,257	24,816	4.9	10.8	268.

[a]Includes eight TFM bars (1.7 kg, 3.7 lbs) applied in Albany Creek.

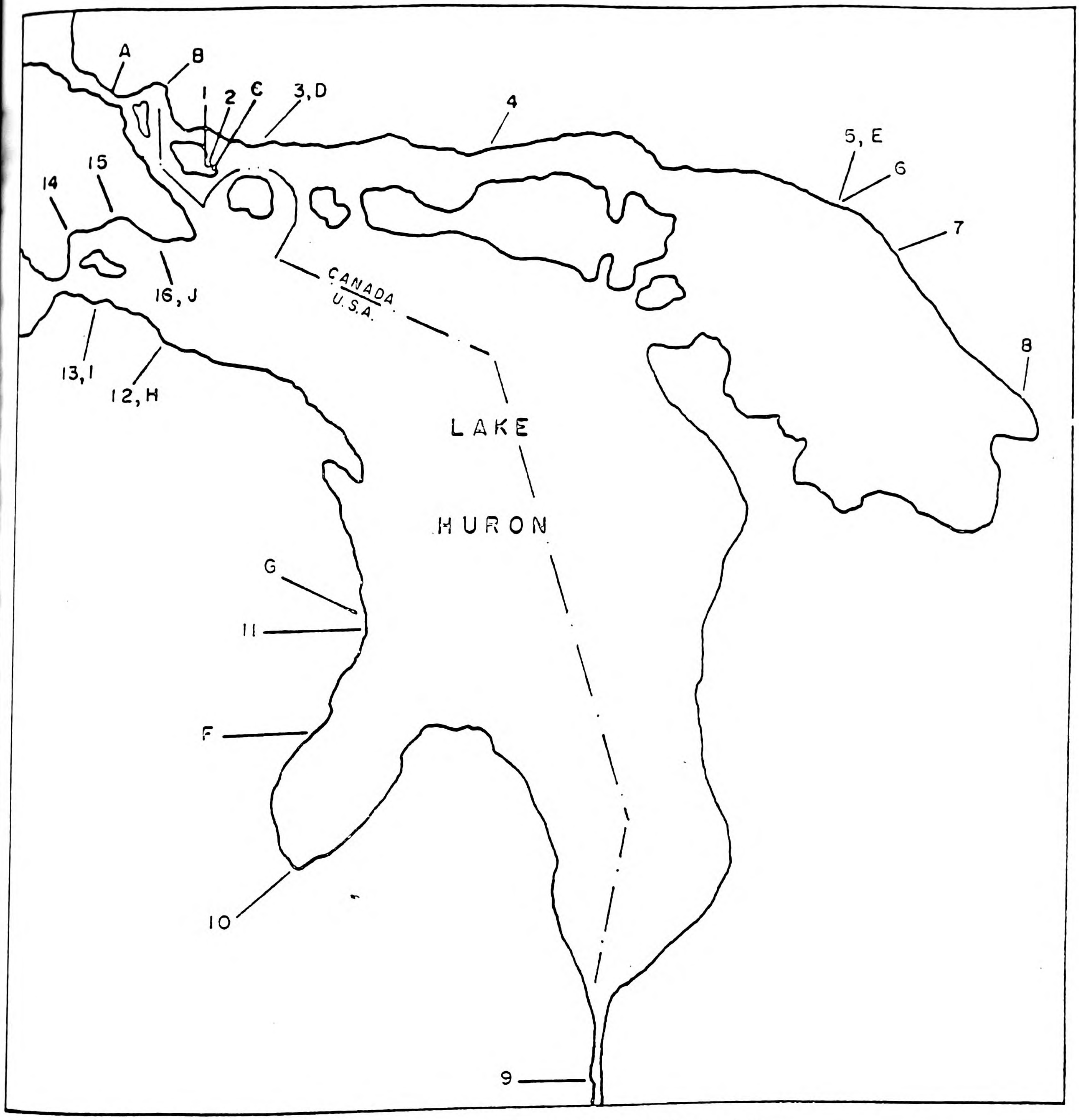

Figure 5. Location of Lake Huron tributaries treated with lampricides (numerals; see Table 10 for names of streams), and of streams where assessment traps were fished (letters; see Table 11 for names of streams) in 1988.

Toxicity tests were conducted before lampricide application on four of th streams. The target treatment concentrations of TFM was determined by a alkalinity prediction chart when test results were significantly higher tha predicted minimum lethal concentrations (MLCs). A combination of toxicity tes and prediction table MLCs were used when cold water or pH fluctuations wer involved.

A toxicity test was conducted on sea lamprey larvae, transforming larvae several fish species, and invertebrates during a TFM survey of the Little Rapid Cut area, St. Marys River. Transforming larvae emerged two hours later from th substrate than other larvae, but 100% mortality was reached in the same hour both life stages. No significant mortality occurred among nontarget species

Canada

Despite the abnormally dry summer, 8 streams, with a combined discharg of 44.8 m^3/s (1,577 f^3/s), were successfully treated with lampricide in 198 (Table 10, Fig. 5). Larval sea lamprey were rated as abundant in the Aux Sable (tributary to Spanish River) and Magnetawan rivers and Browns Creek, and o moderate abundance in the remainder. The relatively low levels of Lake Huro in 1988 aided the movement of lampricide blocks through the estuaries of thes streams. The Musquash River had not been treated since 1970. The others stream are treated according to a regular treatment cycle. Nontarget fish mortali was insignificant in all the streams treated.

The dry summer and resulting low stream flows, especially pronounced the Manitoulin Island area of Lake Huron, did cause deferral of two strea treatments, the Chikanishing River near Killarney, and Timber Bay Creek nea Providence Bay on Manitoulin Island. Timber Bay Creek had never revealed larval sea lamprey population until 1988, when substantial numbers of multi-yea classed animals were discovered. Some numbers of transformers can be expecte to migrate into Lake Huron from each stream. These streams were not treated 1988, but severe repercussions are not expected.

Treatment personnel assisted USFWS treatment crews in the TFM survey o the Little Rapids Cut area of the St. Marys River, by conducting pretreatme bioassays, discharge measurements, and dye studies.

SPAWNING-PHASE ASSESSMENT

United States

During the 1988 spawning season, 29,067 sea lampreys were captured assessment traps placed in 7 tributaries of Lake Huron (Table 11, Fig. 5), a 5 increase over the number taken in 1987 (18,235). The increased catch in La Huron is due to the large number of lampreys trapped in the Cheboygan Riv (25,411 in 1988 vs. 14,790 in 1987). A stratified mark and recovery system us to estimate the number of spawning-phase sea lampreys in the river for the fif consecutive year indicated that sea lampreys were more abundant than in 198 trap efficiency was identical for both years (69%). An estimated 36,645 spawne were in the Cheboygan River compared to an estimated 21,406 in 1987. The cat of lampreys declined in Albany and Van Etten creeks and the East Au Gres Riv by 243, 20, and 434 sea lampreys, respectively.

Table 11. **Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Huron, 1988.**

[Letter in parentheses corresponds to location of streams in Figure 5.]

Stream	Number captured	Number sampled	Percent males	Mean length(mm)		Mean weight (g)	
				Males	Females	Males	Females
United States							
St. Marys River (A)	698	163	69	493	494	270	268
East Au Gres River (F)	7	5	40	458	433	242	177
Au Sable River (G)	103	103	60	465	469	232	243
Van Etten Creek	1	1	0	-	419	-	120
Ocqueoc River (H)	2,771	0	-	-	-	-	-
Cheboygan River (I)	25,411	310	44	460	461	212	220
Albany Creek (J)	76	74	31	442	462	189	222
Total or average	29,067	656	51	471	467	234	231
Canada							
St. Marys River (A)	7,698	1,724	53	483	482	253	259
Lower Echo River (B)	886	257	53	490	489	262	270
Koshkawong River (C)	291	80	45	475	471	228	236
Thessalon River (D)	2,404	594	59	493	494	264	272
Still River (E)	520	120	59	482	505	240	298
Total or average	11,799	2,775	54	486	486	255	263
GRAND TOTAL OR AVERAGE	40,866	3,431	53	483	482	251	257

Fewer lampreys were taken in Albany Creek because some probably bypasse the barrier. The catch in the St. Marys River declined from 1,292 in 1987 t 698 in 1988. This decline likely was a result of intermittent water discharge in the powerhouse tailrace that lowered trap efficiency. A population estimate conducted in cooperation with the Department of Fisheries and Oceans, Canada indicated about the same estimated number of spawning-phase sea lampreys in th river as in 1987 (21,224 vs. 20,840 in 1987). A hoop-fyke net was operate downstream of an electrical weir (Smith-Root) for the second consecutive yea in the Ocqueoc River and captured 2,771 sea lampreys in 1988 compared to 1,35 in 1987. While studies conducted at the weir showed good promise for blockin upstream migrant lampreys, an overall escapement of about 3% due to power failur and a temporarily weak electrical field, demonstrates the need for furthe testing. The total catch of lampreys at Foote dam in the Au Sable Rive increased from 14 in 1987 to 103 in 1988, and may be related to the differen flow conditions prevalent at the site in 1988; most of the tailrace current wa discharged through the trap while only a small portion had been in the past Lampreys taken in 1988 averaged 26 mm longer and 25 g heavier (sexes combined than those in 1987. The percentage males in the sample was 5% higher than i 1987 (51 vs 46%).

Spawning-phase sea lampreys and nests were observed in the Au Sable an Saginaw rivers. A total of 172 adults and 84 nests were counted in the Au Sabl River and 45 adults and 68 nests were observed in 3 tributaries (Flint, Chippewa and Big Salt rivers) of the Saginaw River.

Canada

The spawning runs on five Lake Huron tributaries were sampled in 1988 (Fig 5). A total of 11,799 adults were trapped. Biological data was derived fro 2,775 specimens (Table 11). The total catches in 1987 was 8,665. All th streams showed an increase in 1988 except for the Still River.

Five additional traps were fished on the St. Marys River in 1988 (two i the Great Lakes Power tailrace and three in the rapids), but the 7,698 adult captured is not significantly higher than the 6,982 captured in 1987. The joir DFO/USFWS trap operation yielded a trapping efficiency of 30% (31% in 1987), an a population estimate of 21,224 adults, compared to 20,840 in 1987 for the Saul basin of the St. Marys River.

The catch of 886 adults at the Lower Echo River dam exceeds any previou collections from this site, including 5 years of electric barrier operation i the 1960's. The dramatic increase, compared to 105 in 1987, may be a reflecti of the remedial work done following the 1987 trapping season to preven escapement under this structure.

A catch of 291 adults collected in the Koshkawong River, compares to catch of 177 in 1987. Trap efficiency was 62%. A total run of 426 adults we estimated.

A catch of 520 adults were collected at the barrier dam completed in 198 This is similar to the 554 captured in 1987.

A catch of 2,404 adults from the Thessalon River is considerably higher than the 847 collected in 1987, but less than the 2,695 collected in 1986.

Crews continued to help the Sterile Male Release Technique Task Force (SMRT). Three separate releases of 500 marked natural males, imported from the Cheboygan River, were made in the St. Marys River on May 15, June 1, and June 15, as specimens became available. The objective was to see how well each group would assimilate into the indigenous run and follow normal spawning activities based on time of release. Although the first adults were captured on May 30, the first imports were not trapped until June 7. Totals recaptured from all sources (U.S. and Canadian) showed a recovery rate of 52% for the May 15 release, 28% from the June 1 release, and 15% from the June 15 release. This progressive reduction in the ratio of recapture to release over time is typical of mark recapture studies conducted on the natural run in the system.

One positive aspect was that return patterns from the three releases were similar to that of the normal run and to each other. We will continue to observe the spawning grounds to indicate the value of the method of release. Of 35 adults captured in the St. Marys Rapids, 5 were SMRT imports (two from the first release, two from the second, and one from the third). Accepting that this small sample is representative, then the ratio of returns was even higher on the spawning grounds than from the traps. The ratio of 5 imported males to 13 normal males observed in the rapids, while appearing artificially high, is also favorable. Behavior of the imported males seemed normal, agreeing with the findings from other SMRT initiations. In summary, results support the use of successive releases as an option for SMRT in the St. Marys River.

Nest surveys in the St. Marys rapids to determine success (prolarval production) showed that 23 of 28 positive nests yielded prolarvae; a success rate of 82%, compared with a success rate of 87% in 1987. This technique may be used as an index to measure the impact of a sterile male program.

PARASITIC-PHASE ASSESSMENT

United States

A total of 1,195 sea lampreys were collected by commercial fishermen in Lake Huron (Table 6), compared with 1,152 taken in 1987. Fishermen from statistical district MH-1 (DeTour-Rogers City, Michigan, area) contributed the largest number of sea lampreys (843) and the number was down slightly from that taken in 1987 (943). The number of sea lampreys collected by a single commercial fisherman in statistical district MH-2 (Alpena, Michigan, area) decreased from 1987 (136) to 1988 (67), but the operator did not fish in July and August in 1988. Fishermen from the statistical district MH-4 (Tawas City-Bay Port, Michigan, area) captured 285 sea lampreys in 1988, a significant increase from the 73 taken in 1987.

Spawning year was determined for 1,195 parasitic-phase sea lamprey collected by the commercial fisheries; 251 would have spawned in 1988, 939 i 1989, and 5 in 1990 (Table 6). In addition, 979 lampreys of the 1988 spawnin year were taken in 1987, bringing the total collected for this spawning year t 1,230 (Table 6). This represents an increase in the number of parasitic-phas sea lampreys captured by commercial fishermen (884 of the 1987 spawning year vs 1,230 of the 1988 spawning year).

Anglers on the U.S. side of Lake Huron captured 2,526 parasitic-phase se lampreys (336 from charter and 2,190 from noncharter fishermen) in 1988, compared with 2,227 (284 charter and 1,943 noncharter) in 1987 (Table 6) Lampreys were collected from all statistical districts on Lake Huron, but mor were taken from MH-2 (804; Rogers City to Black River, Michigan, area) than othe districts. Lakewide, 88% of the lampreys collected from the noncharte sportfishery were attached to chinook salmon. Through a cooperative agreemen initiated in 1988 with the Michigan Department of Natural resources, we wil obtain information on the occurrence of sea lampreys from the entire Michiga charter boat fleet.

Fyke nets were fished in the Tittabawassee River in November to evaluat the downstream migration of recently metamorphosed sea lampreys. The nets wer fished 14 days in November and five transformers were captured. An estimate range of 321 to 3,205 sea lampreys migrated downstream during the period.

Canada

Lake Huron commercial fishermen reported 1,114 parasitic-phase lamprey in 1988 (670 from the North Channel and 444 from the main basin). The tota count is slightly higher than the final 1987 tally of parasitic-phase lampreys Collections from a group of long-time contributors, for both the North Channe and northern main basin show an increase in the North Channel which breaks th recent downward trend following the 1984 peak. Counts from the northern mai basin have remained steady since 1984.

Monitoring of the two chinook salmon derbies in the St. Marys Rive continues on an annual basis. During the "Coors King Salmon Derby," conducte in the Sault Ste. Marie to De Tour area from August 20 to September 10, 74 chinook salmon were entered. A check of 411 of these fish showed a marking rat of 56% and a wounding rate of 45% (66 wounds/100 fish).

The "Can-Am Tournament," running from September 16 to September 18 for th immediate Sault Ste. Marie portion of the St. Marys River, produced 112 chinoo (67 were sampled for lamprey information). A marking rate of 61% was recorde with 34% wounded (64 wounds/100 chinook).

From 1985 to 1987, combined results from these two derbies show high b stable wounding rates at just under 44/100 chinook. In 1988, the combined ra rose to 66 wounds/100 chinook.

LAKE ERIE

LARVAL ASSESSMENT

United States

A total of 11 tributaries of Lake Erie were surveyed in 1988 to assess sea lamprey populations and to locate new infestations. Recruitment of sea lampreys was assessed in ten streams by sampling index sites. The 1988 year class was found only in Cattaraugus Creek.

Four yearling larvae were recovered from Crooked Creek and one transforming larvae was collected from the Buffalo River. No sea lampreys were recovered in Delaware, Canadaway, Raccoon, Conneaut, and Wheeler creeks, Halfway Brook, and the Grand River. High water levels may have negatively affected the reliability of the surveys.

The Maumee River was surveyed for evidence of sea lamprey reproduction. Spawning adult sea lampreys had been reported at the Providence dam in Grand Rapids, Ohio, in April 1988. Fourteen sites were sampled by electrofishing and Bayer 73 granules, but no sea lampreys were recovered. Extremely low water conditions and high water temperatures may have resulted in high larval mortality if spawning had occurred.

Canada

Surveys were conducted on 11 Lake Erie and 5 Lake St. Clair tributaries to monitor reestablished and residual populations, and to look for new infestations.

Of the 10 Lake Erie streams treated in the fall of 1986 and spring of 1987, 6 had reestablished larval populations. They are: Big Otter, Clear, Big, Forestville, Normandale, and Youngs creeks. Surveys were performed too early in the year to detect the 1988 year class and fall surveys were cancelled.

Small numbers of residual sea lamprey larvae were collected from five streams: East, Big Otter, South Otter, Big, and Youngs creeks.

Five Lake St. Clair tributaries were surveyed. One sea lamprey larvae was found in Komoka Creek (a tributary of the Thames River). All other tributaries were negative. Lake St. Clair tributaries were difficult to survey by electroshocking because of turbid water and high conductivities. The Thames River is scheduled for additional work in 1989.

SPAWNING-PHASE ASSESSMENT

United States

A total of 1,903 sea lampreys were captured in assessment traps placed three tributaries of Lake Erie (Table 12, Fig. 6), about the same number tak in 1987 (1,958). The average length and weight of lampreys sampled in 19 remained about the same as those taken in 1987, but the percentage mal increased from 52 to 63%. Lampreys taken in tributaries of Lake Erie contin to be larger and heavier than those taken in the other lakes, a characterist prevalent since sampling began in 1980.

Canada

The Grand River was surveyed for spawning-phase sea lampreys to determi nesting success. The effort was concentrated below the new dam at Calendon where past observations revealed nests and adult activity. In 1988, only o pair of adults were observed in nest construction, but three other nests we identified. Two of the successful nests yielded prolarvae to stage 14 and 1 Larger sized larvae were not found in granular Bayer surveys below Calendon in turbid waters.

Table 12. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Erie, 1988.

[Letter in parentheses corresponds to location of streams in Figure 6.]

Stream	Number captured	Number sampled	Percent males	Mean length (mm) Males	Mean length (mm) Females	Mean weig Males
Cattaraugus Creek (A)	1,615	1,075	64	506	502	305
Grand River (B)	257	253	55	508	498	280
Chagrin River (C)	31	29	72	515	499	291
Total or average	1,903	1,357	63	506	501	301

PARASITIC-PHASE ASSESSMENT

Canada

By the end of 1988, only 55 sea lamprey were submitted to the Centre fr cooperating Canadian commercial fisheries. This is lower than 1987, when 3 were received, and 1986 when 454 were submitted. The decreased returns from t eastern basin were most pronounced and the central basin shows a similar tren Small catches in the western basin show no appreciable trend.

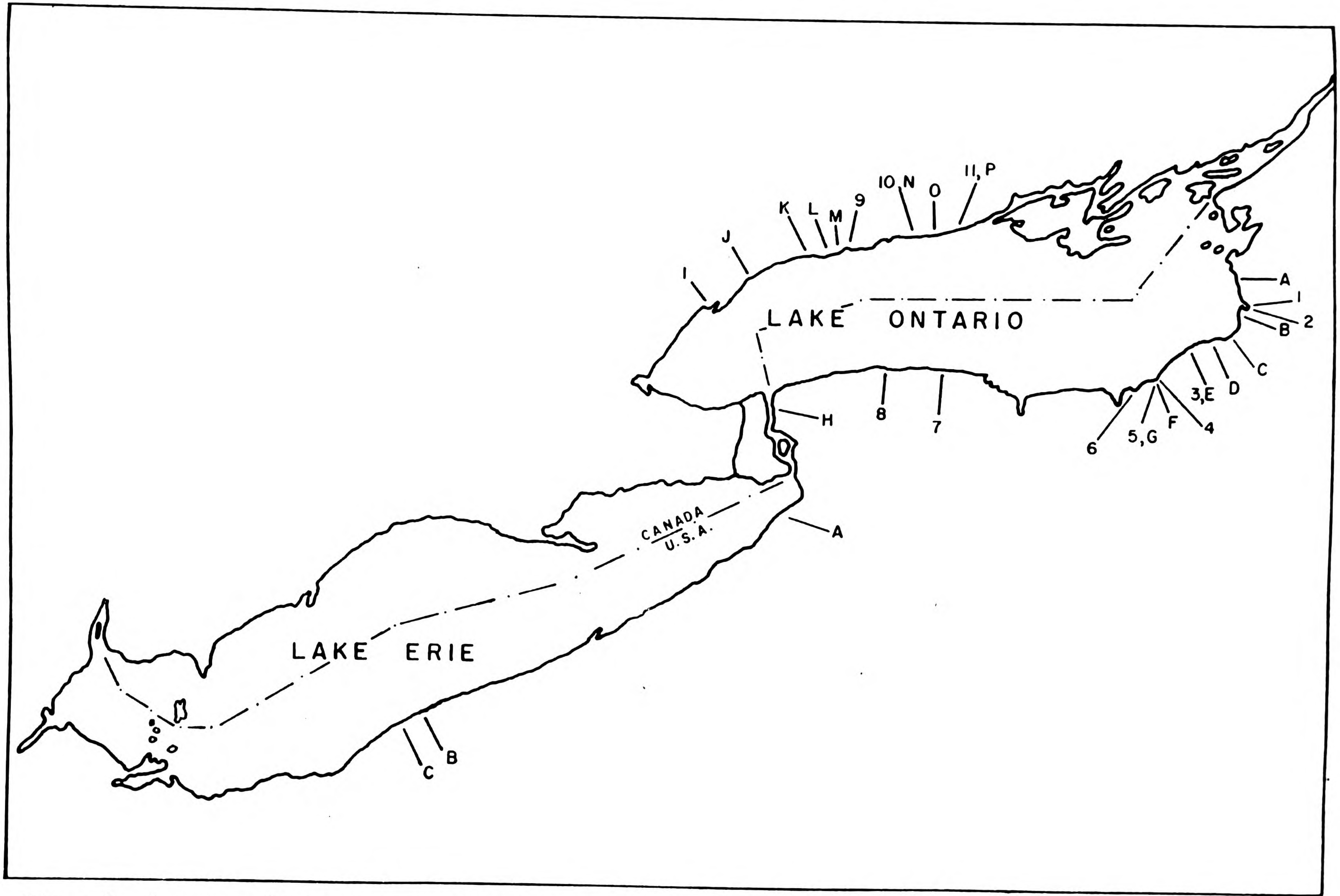

Figure 6. Location of Lakes Erie and Ontario tributaries. (Letters; see Table 12 for names of streams where assessments traps were fished on Lake Erie) (Numeral; see Table 13 for names of streams on Lake Ontario chemically treated with lampricides). (Letters; see Table 14 for names of streams where assessment traps were fished.

Low-Head barrier dams were constructed on two small tributarie
Forestville and Normandale creeks. The steel sheet piling structures were buil
by Sea Lamprey Control Centre staff at a cost (including field travel expense
of $11,426. The Normandale dam incorporates a jumping pool, which wa
prefabricated at the Centre. The Forestville barrier dam does not incorporat
a jumping pool. The barrier dam was designed at the request of the Ontari
Ministry of Natural Resources, to stop salmonid passage and protect a brook tro
population in the headwaters of this stream.

LAKE ONTARIO

LARVAL ASSESSMENT

United States and Canada

Surveys of Lake Ontario streams were conducted at index sites o
tributaries of the Oswego River system to assess recruitment of sea lamprey
Sea lamprey larvae were recovered in Carpenter (28 larvae; 66-137 mm) and Col
Spring (47 larvae; 44-168 mm and 6 transformers) brooks, but none were collect
in Crane Brook.

Surveys were conducted on 45 Lake Ontario tributaries and two delta area
in 1988. Surveys prepared for chemical treatments, monitored reestablishe
residual, and untreated populations, and searched for new infestations.

Distribution surveys were completed on 17 streams, 6 of which we
subsequently treated in 1988. A massive beaver dam, about 4 km from the mou
of Snake Creek, appears to have blocked spawning-phase lampreys since the la
(1986) treatment. This will shorten the treatment by 10.5 km, and simplify t
1989 treatment.

Treatment evaluation surveys on nine streams treated in 1987 fou
significant numbers of residual larvae in Little Sandy Creek and the Black Riv
in New York State. Little Sandy Creek is on the 1989 treatment schedule.
will evaluate the Black River residual population in 1989. In the Credit Rive
a small population of sea lamprey larvae exists in a drained impoundment are
immediately above the 1987 application point. This was not unexpected becau
a dam at this location was breached in the fall of 1985. Small numbers
residual larvae were found in South Sandy and Grindstone creeks and none we
taken from Catfish, Lynde, and Oshawa creeks or the Rouge River.

Evaluation surveys on four streams treated in 1988 found significa
numbers of residual lampreys in Skinner and Lindsey creeks, but none in Graft
and Salmon creeks. The larvae collected from Skinner and Lindsey creeks ca
primarily from spring seepage and backwater areas in stream reaches with hi
pretreatment larval densities. Survey work is scheduled for both streams
1989.

Of the nine streams treated in 1987, Lynde, Oshawa, South Sandy, Little Sandy, and Grindstone creeks have reestablished with the 1987 year class, but Catfish Creek and the Black, Rouge, and Credit rivers appear to have not reestablished with sea lampreys. Most Lake Ontario surveys were done too early to detect the 1988 year class, with the one exception, the Black River, where six young-of-the-year larvae were collected in a July survey.

Population study surveys were done on several streams with a recent record of sea lamprey populations, but in numbers too small to justify treatment. These include Sage, Black (a tributary to the Oswego River), Sodus, and Northrup creeks in New York State and Sixteen Mile and Duffins creeks, and the Moira and Salmon rivers in Ontario. Larval density remains low in all of these tributaries.

Moderate numbers of the 1987 year class of larval sea lampreys were collected in Shelter Valley Creek in September, 1987 below the barrier dam (constructed in 1985). In 1988, no larvae could be found in the 0.4 km of suitable spawning gravel and larval habitat below the dam. Granular Bayer surveys off the stream mouth did not produce larvae.

Larval sea lampreys were found for the first time in the main stem of the Trent River above the outlet of Mayhew Creek, a known producer. Surveys suggest that these larvae (a low density, multi-year class) originate from spawning nests immediately downstream of the lowermost power dam. Bottom dredgings in the lower Trent River indicate a gradual improvement in larval habitat in recent years due to industrial pollution abatement.

CHEMICAL TREATMENT

United States

Lampricide treatments were conducted on eight tributaries to the New York side of Lake Ontario and on Big Bay Creek, a tributary to Oneida Lake (Table 13, Fig. 6). The planned treatment of Fish Creek, a large tributary system on Oneida Lake, was deferred until 1989 because of excessive discharge late in the fall.

Favorable spring run-off conditions facilitated successful treatments of Skinner, Lindsey, Sterling, Ninemile, and Red creeks. Larval lampreys were abundant in Skinner and Lindsey creeks, moderately abundant in Ninemile and Sterling creeks and scarce in Red Creek. Several hundred white suckers were killed during the treatment of Red Creek, as were moderate numbers of logperch and shiner spp. during the treatment of Sterling Creek.

Marsh Creek (a tributary to Oak Orchard Creek) and Salmon Creek, located west of Rochester and first discovered to harbour larval sea lampreys in 1986, were treated for the first time. Despite low flows, effective treatment levels had a minimal effect on nontarget fishes. Although relatively small in terms of discharge and length, moderate numbers of larval sea lampreys were observed during the treatment. Multiple year-classes and larvae of transformation size were collected.

Table 13. Details on the application lampricides to streams of Lake Ontario, 1988. [Number in parentheses corresponds to location of stream in Figure . Lampricide used is in kilograms/pounds of active ingredient.]

Stream	Date	Discharge m^3/s	Discharge f^3/s	TFM[a] kg	TFM[a] lbs	Stream km	Stream mil
UNITED STATES							
Skinner Cr. (1)	May 6	1.1	40	158	348	12.6	7.8
Lindsey Cr. (2)	May 8	0.7	23	159	351	20.1	12.5
Oak Orchard Cr. (8) Marsh Cr.	May 8	0.1	4	34	75	8.8	5.5
Sterling Cr. (5)	May 11	1.0	35	348	767	7.5	4.7
Salmon Cr. (7)	May 11	0.6	22	141	311	11.3	7.0
Ninemile Cr. (4)	May 13	0.5	15	221	487	12.4	7.7
Red Cr. (6)	May 15	0.4	13	133	293	14.5	9.0
Oswego R. Big Bay Cr. (3)	Oct 20	0.4	13	76	168	8.3	5.2
Totals		4.8	165	1,270	2,800	95.5	59.4
CANADA							
Lakeport Cr. (11)	May 15	0.3	12	75	165	0.8	0.5
Grafton Cr. (10)	May 15	0.2	8	69	152	4.1	2.6
Port Britain Cr. (9)	May 17	0.2	7	105	231	7.4	4.6
Totals		0.7	27	249	548	12.3	7.7
GRAND TOTAL		5.5	192	1,519	3,348	107.8	67.1

The treatment of Big Bay Creek was complicated by low discharge at the beginning of the treatment and then heavy rains near its conclusion. Larval sea lampreys were moderately abundant, with the majority of the 390 collected specimens composed of the 1984 and 1985 year classes (39 percent actually transforming). Despite lampricide concentrations being maintained at target levels, moderate mortality of white suckers, shiners, grass pickerel, brown bullheads, and darters occurred throughout the stream.

Canada

Three small tributaries were effectively treated with the lampricide TFM in 1988 (Table 13, Fig. 6). The treatments of Port Britain and Grafton creeks were similar to their five previous treatments (since 1971). The application sites remained the same, but the treatment of Lakeport Creek was reduced to 0.8 km from the 15 km historically treated. A low-head barrier dam constructed in 1984 has been effective in preventing adult migration above this dam.

Sea lamprey larvae were moderately abundant in all three streams. Nontarget fish mortality was insignificant on Lakeport and Grafton creeks, but a 2.5 km stretch of Port Britian Creek had a significant mortality of logperch.

SPAWNING-PHASE ASSESSMENT

United States

A total of 193 sea lampreys were captured in assessment traps placed in eight tributaries (two more streams than in 1987) of Lake Ontario (Table 14, Fig.6) in 1988 compared to 501 in 1987. Trap catches declined in five of the six streams monitored in both years. Reductions in Sterling and Sterling Valley creeks are partially attributed to lampricide treatments that coincided with the week of peak migration during the spawning run. A specially designed assessment trap placed at the Robert Moses Power Project in the Niagara River was operated through a volunteer agreement with the Niagara River Sportsman Association. The trap functioned properly and, although no sea lampreys were captured, hundreds of fish including several American eels were taken. This high capture rate of fish suggests that the trap would have captured lampreys if they were present at the site in significant numbers. No additional work in the river is planned at this time. Traps placed in the Oswego River for the first time since 1978 captured no sea lampreys. Lampreys taken in Lake Ontario tributaries averaged 76 mm shorter but 19 g heavier than those taken in 1987 while the percentage males declined by 8% (74 to 66%).

In 1988, efforts were made to estimate the total number of spawning-phase sea lampreys in U.S. waters of Lake Ontario using the same method developed previously in Lake Superior. The method is based on a relation between average stream discharge and the number of adult lampreys that enter tributaries to spawn.

While all the flow data necessary to conduct the estimate was collect in-stream estimates of spawning-phase sea lampreys could not be calcula because of coincidental lampricide treatments in certain tributaries and recaptures of lampreys in others, thus an estimate of the total number lampreys was not possible in 1988.

Canada

With the addition this year of the Grafton Creek barrier dam trap, a to of eight streams were monitored in 1988 (Fig. 6). The total number of adu was 5,374. Biological data from representative samples is listed in Table Despite this additional stream, the total catch was well below that for 1987 w 8,190 adults were captured.

Trap efficiency/population estimate studies on four streams concluded following determinations: Humber River - 43%/5,171, Duffins Creek - 57%/1,8 Graham Creek - 43%/170, and Shelter valley Creek - 78%/1,217. Individual catc and run estimates from these four streams also demonstrate a downturn.

At 52% males, the sampled sex ratio is the third drop since the 1986 p of 65%. Average lengths and weights for both sexes are on a downward trend

Field investigations were conducted on three streams to ascertain success of individual nests to yield prolarvae. On the Humber River, 12 ne were found to be positive (contained eggs or prolarvae) and two provi prolarvae to Stage 15. Salem Creek had a 93% success rate (some to Stage on 30 positive nests. In the Trent River, 5 of 7 positive nests that were int by the end of the season, yielded prolavae for a success rate of 71%.

The old mill dam, 3.9 km above the mouth of Bowmanville Creek, was effective lamprey barrier until it was breached in the fall of 1986. A dam the Goodyear Plant in Bowmanville, about one kilometer below the mill dam previously only a lamprey deterrent, was improved during the summer to make lamprey proof. As an interim measure to prevent adult mirgration into a 20 stretch of excellent spawning habitat, a wooden drop-chute was installed at Goodyear Dam in the spring of 1987 and 1988 by Centre personnel and Bowmanville Creek Anglers Association. The improved Goodyear Dam has a bui in adult sea lamprey trap.

Table 14. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Ontario, 1988.

[Letter in parentheses corresponds to location of streams in Figure 6.]

Stream	Number captured	Number sampled	Percent males	Mean length (mm)		Mean weight (g)	
				Males	Females	Males	Females
UNITED STATES							
South Sandy Creek (A)	0	-	-	-	-	-	-
Grindstone Creek (B)	24	8	63	422	370	199	160
Little Salmon River (C)	3	0	-	-	-	-	-
Catfish Creek (D)	0	-	-	-	-	-	-
Oswego River (E)	0	-	-	-	-	-	-
Sterling Valley Creek(F)	125	115	66	428	420	241	240
Sterling Creek (G)	41	0	-	-	-	-	-
Niagara River (H)	0	-	-	-	-	-	-
Total or average	193	123	66	428	416	238	234
CANADA							
Humber River (I)	2,509	472	50	475	465	257	254
Duffins Creek (J)	1,094	211	52	482	477	261	268
Bowmanville Creek (K)	537	504	52	492	487	266	270
Wilmot Creek (L)	44	44	43	477	483	273	268
Graham Creek (M)	94	32	44	449	459	241	234
Grafton Creek (N)	12	12	42	459	479	223	251
Shelter Valley Creek (O)	1,015	292	55	486	480	259	260
Lakeport Creek (P)	69	69	52	459	472	232	257
Total or average	5,374	1,636	52	482	477	260	262
GRAND TOTAL OR AVERAGE	5,567	1,759	53	477	474	258	260

LAKES SUPERIOR, MICHIGAN, AND HURON

Treatment Effects on Nontarget Organisms (short-term test)

United States

Caged studies--Routine monitoring of the immediate effect of lampricide upon nontarget organisms continued in 1988. An in situ assay was completed b caging fish in the Bad River and fish and invertebrates were tested in flow through assay facilities in the St. Marys River.

Small fish (<22.8 cm, 9 inches) were collected by electrofishing an acquired from hatcheries and bait dealers. Lake sturgeon were provided by th Minnesota Department of Natural Resources for the Bad River test. Invertebrate were removed from the substrate by a suction dredge or by electrofishing. Onl uninjured specimens were used in the test. As a control, specimens were place in the areas to be treated the day before lampricide application. They wer later removed and replaced by additional specimens. The same group of lak sturgeons were used in control and treatment because of a limited supply o specimens.

A total of 16 species of fish were caged at four locations in the Bad Rive watershed to monitor the effects of the lampricide treatment on nontarget fis (Table 15). These included 15 species collected from the river, and the lak sturgeon. Of those collected from the river, the largescale stonerolle (Campostoma oligolepis) was the first confirmed report of that species in th Lake Superior drainage (identification confirmed by Dr. Fred Copes, Universit of Wisconsin, Stevens Point).

A low mortality was observed in caged fish collected from the stream i control (5 of 181) and treatment (6 of 188) tests. Lake sturgeon caged at tw mainstream locations (Government Road bridge and upstream at section 25/3 rapids) suffered higher mortalities during the treatment test (29 of 30 or 97 at Government Road bridge and 2 of 10 or 20% at the upstream site). The sam sturgeon were used as both control and treatment specimens, and those a Government Road bridge had been held for over seven days by the time they wer subjected to lampricide. The lower mortality observed upstream was at a TF concentration higher than that experienced by the fish at Government Road an suggests that those fish were overly stressed prior to the arrival of th lampricide bank.

Survival was excellent among invertebrates (mayflies and crayfish; 100 for 68 specimens) and five species of fish (white sucker, fathead minnow, johnn darter, creek chub, and sculpin spp.; 94% for 79 specimens) held in tanks of flow-through bioassay facility during a chemical survey of part of the St. Mary River.

Table 15. Number of fish alive and dead of those caged for 24 hours before treatment (control), and the number alive and dead after treatment of those caged during TFM application (treatment) in the Bad River (rapids area) and two of its tributaries, Potato and Marengo rivers, in 1988.

	Bad River				Potato River				Marengo River			
	Control		Treatment		Control		Treatment		Control		Treatment	
Species of fish	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead
Common shiner *Notropis cornutus*					18	0	12	1	7	3	6	2
White sucker *Catostomus commersoni*	2	0	1	0	4	0	9	0	10	0	10	0
Hornyhead chub *Nocomis biguttata*	6	0	4	0	12	0	13	0	2	0	3	0
Creek chub *Semotilus atromaculatus*			2	0	5	0	1	0	7	0	8	0
Largescale stoneroller *Campostoma oligolepis*	3	0	1	0	2	0	3	0				
Smallmouth bass *Micropterus dolomieui*	10	0	10	0	7	1	8	0	5	0	7	0
Blacknose dace *Rhinichthys atratulus*					8	0	12	0	9	0	7	0
Longnose dace *Rhinichthys cataractae*	10	0	10	0					1	0	3	0
Slimy sculpin *Cottus cognatus*					2	0	2	0	3	0	3	1
Bluntnose minnow *Pimephales notatus*					1	0	1	0	1	0	1	0
Johnny darter *Etheostoma nigrum*	9	1	8	0					10	0	9	1
Logperch *Percina caprodes*	16	0	16	0					2	0	2	0
Central mudminnow *Umbra limi*											1	0
Rock bass *Ambloplites rupestris*	4	0	9	1								
Bluegill *Lepomis macrochirus*			1	0								
Lake sturgeon *Acipenser fulvescens*	10	0	8	2								
	[a]30	[a]0	[a]1	[a]29								

[a]Caged at Government Road Bridge.

Invertebrate drift--Mortality estimates on selected organisms have bee determined from caged specimens in streams during treatments since 1983. Sor organisms must be assessed by other techniques because of their small size scarcity, inability to survive in cages, or difficulty in being collecte Sampling of invertebrate drift is a valuable method to determine which speci are sensitive to the chemical, although estimates of the percentage which late die cannot be determined by the technique. The use of drift studies, combination with other sampling methods, provides the best evaluation on community-wide basis.

Invertebrate drift was sampled during the 1988 chemical survey of th Little Rapids Cut area of the St. Marys River. Drift nets were attached to rigid frame secured to the bow of a boat and designed to collect samples at th water surface and near the bottom in 10 feet of water. The nets were fishe continually (each net was emptied every two hours until midnight when they wer left until morning) for the 12 hours of the survey and, as a control, for similar time frame before the survey. TFM concentration was maintained betwe the minimum lethal dose for larval lampreys (MLC, concentration killing 99.9 of the test larvae within 9 hours) and maximum allowable dosage (MA concentration predicted to kill 25% of test rainbow trout within 24 hours) the river. During the survey, MLC (or up to 1.2 times MLC) was maintained fo 8 hours.

Drift increased 164% from pre-survey samples to samples taken during th survey (Table 16). In general, the increase was attributed to a few organisms Cladocerans, especially Pythotrephes cedarstroemi, and copepods increased 14 and 194 percent, respectively. Trichopterans and Hydracarina sp. were abser in pre-survey samples, but present in small numbers in survey samples. Mor organisms were collected in the surface net than the net fished near the bottom The number of organisms collected per hour during both periods decreased steadil during the morning, afternoon, and early evening hours, then increased afte dark, and reached a peak after midnight. Apparently, the lampricide did no affect the daily diurnal cycle, but rather effected an increase in the numbe and types of organisms composing the drift.

Mayflies--Samples of Hexagenia and Ephemera were collected before and afte the chemical survey of the Little Rapids Cut area in the St. Marys River t compare to assay results. Random samples (3 from each of 10 silt beds; tota of 30 samples for each period) were collected with an Eckman dredge. There wa no significant difference in the average abundance of Hexagenia or Ephemer nymphs/m^2 in each silt bed between pre- and post-survey periods. The pre- an post-survey number of mayflies/m^2 respectively averaged: Hexagenia - 853 and 83 Ephemera - 603 and 578.

Hexagenia were sampled in the Pere Marquette River (Lake Michigan) t determine recovery of the population following the 1987 treatment of the rive At that time, total abundance of nymphs declined 69% from the pretreatmen (754/m^2) to posttreatment (230/m^2) samples. Abundance of nymphs in 1988 average 1,674/m^2. The samples were dominated by age I nymphs (1987 cohort) that were the egg stage during the 1987 treatment and thus unaffected. Further sampli in 1989 will determine the success or failure of the affected 1986 cohort produce nymphs.

Treatment Effects on Nontarget Organisms (long-term test)

United States

Hexagenia--Samples of Hexagenia were collected in the spring and fall in the Whitefish River (Lake Michigan) to determine effects of lampricides on the population. Random samples (3 from each of 10 silt beds at a control and a treated area, or 60 samples) were collected with an Eckman dredge. Originally, Scott Creek (Whitefish River tributary) was selected as the control area in 1984. The site was later abandoned because beavers caused the area to flood. An untreated portion of the nearby Indian River, a tributary of the Manistique River, replaced Scott Creek as the control area in the fall of 1986.

Table 16. Total number of organisms sampled in drift nets at the surface and near the bottom the day before chemical survey (control) and at corresponding periods on the day of application of lampricide (treatment) during survey of the Little Rapids Cut area in the St. Marys River[a] in 1988.

	Control			Treatment		
Taxa	Top	Bottom	Total	Top	Bottom	Total
Ephemeroptera						
Heptageniidae						
Stenacron				2		2
Caenidae						
Caenis					1	1
Ephemeridae						
Hexagenia	2		2	3	4	7
Ephemera					1	1
Hemiptera						
Corixidae	1		1	2	1	3
Trichoptera						
Psychomyiidae						
Psychomyia					1	1
Polycentropidae						
Polycentropus				1	1	2
Hydroptilidae						
Hydroptila				1	2	3
Leptoceridae						
Mystacides					1	1
Setodes					1	1
Diptera						
Chironomidae	17	7	24	10	8	18
Simulidae						
Simulium					2	2
Annelida						
Oligochaeta	4	2	6	8	19	27
Cladocera				15		15
Bythotrephes	351	62	413	1276	386	1662
Daphnia	116	70	186	231	201	432
Holopedium	390	312	702	705	431	1136
Copepoda	462	315	777	1627	659	2286
Ostracoda		1	1	1		1
Amphipoda						
Talitridae						
Hyalella	4		4	1	1	2

(continued)

Table 16. Continued.

Taxa	Control Top	Control Bottom	Control Total	Treatment Top	Treatment Bottom	Treatment Total
Amphipoda (continued)						
Gameridae						
Gammarus	1		1		1	1
Gastropoda						
Hydrobiidae						
Somatogyrus	3	2	5	1		1
Amnicola	1		1			
Planorbidae						
Planorbula	1		1	2	2	4
Acarina						
Hydracarina				5	2	7
Pisces						
Serranidae						
Ambloplites		1	1			-
Total	1353	772	2125	3891	1725	5616

[a]Nets were set for 24 hour periods, beginning at 0800, and emptied every 2 hours until 2300 hours when they were left until 0700 hours the following morning.

Total abundance of Hexagenia nymphs in the Whitefish River continued t downward trend exhibited since a 1986 chemical treatment. The number of nymp declined 30% from 70/m^2 in October 1987 to 49/m^2 in October 1988. At the Indi River control site, the number of nymphs increased 122% from 306/m^2 in Octob 1987 to 681/m^2 in October 1988. Both areas were examined at the height of t drought, and found to be sufficiently submerged to allow continued colonizati by nymphs. The decline in nymphs in the Whitefish River may continue into t future. The stream has been treated on a 3 year cycle since the early 1960' Rebound of the mayfly population may occur if treatments are delayed by one yea To monitor the mayfly population, a portion of the East Branch that contains t sample plots will not be treated in 1989, the next scheduled treatment date f the stream.

Riffle Community Index--Index areas of invertebrate communities we established in treated and control sections of the Whitefish (Lake Michigan) a Sturgeon (a tributary of the Cheboygan River, Lake Huron) rivers in 198 Initial samples were collected in the fall of 1985 at control and treated are upstream and downstream of the lamprey barrier in the Whitefish River. Becau of problems associated with comparability of control and treated areas in t Sturgeon River (little diversity in numbers of species and inadequate sampl of the species present at the control area), a control area was selected in untreated portion upstream of dams in the Boardman River (Lake Michigan) spring 1986.

Samples have been collected in the spring and fall at areas using the standard travelling kick method (STKM). The investigator holds a standard D-frame, invertebrate kick net (30.5 cm x 15.2 cm, 12 x 6 inches) in his forward path, then moves downstream for 30 seconds along 4 m (13.1 feet) of stream bottom. Collections were taken before and after chemical treatments of the index streams (Whitefish River 1986, and Sturgeon River 1988). Samples from the Whitefish and Sturgeon rivers have been sorted and identified through 1987. These long-term studies in invertebrate community structure require the establishment of several years of data to draw conclusions that relate to stream treatments.

The results have shown little difference in changes in invertebrate populations between control and treatment areas (Tables 17 and 18). Both the abundance and number of invertebrate taxa declined immediately following the 1986 treatment of the Whitefish River. By October of the same year, the abundance and the number of taxa present had recovered and were at levels above those observed in pretreatment samples. This action occurred at the treated site even as abundance declines were apparent at the control area.

The construction of a lamprey barrier on the Brule River provided the opportunity to design a study on invertebrate communities that included index sites upstream and downstream of the barrier in a regularly treated stream to follow both community structures as the upstream site is phased out of lampricide applications. The barrier was completed in 1985 and initial samples were collected that fall (the sampling schedule includes spring and fall collections through a minimum of two treatment cycles). Collections were taken from each site before and immediately after lampricide treatment in 1986. The treatment included both areas of the river, but the scheduled 1989 treatment will include only the area downstream of the barrier. Samples have been sorted and identified through the 1988 collection (Table 19). The lampricide application in August 1986 did not reduce the total number of organisms in the Brule River (GLFC Annual Report, 1987). Total abundance of organisms increased from pretreatment to posttreatment samples, and this trend continued into 1987. By fall 1987, total abundance was over 10 times higher than before chemical treatment of the stream. Abundance declined somewhat from 1987 to 1988, but remains at much higher levels than 1986 pretreatment abundance.

Table 17. Mean number of organisms from five samples taken by kick nets in riffle communities in the Whitefish River in 1986 and 1987 in areas that are periodically treated and in areas that are not treated (control).[a]

[Whitefish River on Lake Michigan was treated in August 1986.]

	Treated Site						Control Site					
	1986				1987		1986				1987	
Taxa	Spring	Before	After	Fall	Spring	Fall	Spring	Before	After	Fall	Spring	Fall
Collembola												
Entomobryidae	0.2					1.8	0.2	0.2		0.2	0.2	
Ephemeroptera								0.2	0.2			
Baetidae												
Baetis	47.2	112.4	56.8	0.6	102.0	0.8	11.2	55.8	53.8		60.4	0.8
Pseudocloeon	0.2	26.8	21.4	4.2	0.2	7.6	0.4	16.0	18.6	6.0	0.2	11.6
Oligoneuriidae												
Isonychia	2.0	3.0	2.8	4.6	0.4	5.2	2.2	2.8	3.2	3.0	1.8	14.4
Heptageniidae							1.4		0.4			
Epeorus	59.6	1.0	0.6	93.0	42.6	70.8	34.0		0.8	57.4	64.6	46.8
Leurocuta	7.0	4.0	2.4	31.0	9.2	37.0	7.0	5.2	6.2	12.8	19.2	62.4
Rhithrogena												
Stenacron	0.2			0.8		0.2						
Stenonema	22.6	66.8	43.2	46.0	11.0	51.6	6.2	42.0	58.8	23.0	18.0	87.6
Ephemerellidae		3.0	9.2	0.2	0.2			3.0	3.4			
Drunella	91.6				75.8		49.8				21.4	
Ephemerella	167.0			349.0	119.4	175.8	58.8		0.8	179.4	125.8	244.0
Eurylophella		0.2		5.0		6.2	1.0	1.6		0.4	0.8	9.6
Serratella	69.0	1.0	5.8	57.2	57.0	77.6	24.6	3.6	0.4	24.6	20.2	65.8
Tricorythidae												
Tricorythodes			0.2									
Caenidae												
Caenis	0.8	10.8	3.4	10.4	1.8	2.2		1.4	1.6	0.8	1.2	2.0
Leptophlebiidae												
Paraleptophlebia	21.4	4.8	3.6	78.0	26.2	80.0	36.2	3.8	5.6	36.4	35.6	81.4
Ephemeridae												
Ephemera			0.2	0.2	0.2	0.4						
Adults	0.2	0.2					0.2	0.4				
Odonata												
Gomphidae									0.2	0.2	0.2	
Arigomphus												
Ophiogomphus	3.2	5.8	4.6	3.6	4.2	3.6	1.8	7.2	9.8	5.4	5.6	14.0
Stylogomphus	1.4	2.2	3.4	6.0	1.0	1.6	0.8	4.4	4.0	2.6	1.2	4.8
Cordulegastridae												
Cordulegaster								0.2				
Aeshnidae												
Boyeria	1.0		0.2	0.4	0.2		0.2	0.2	0.2			
Calopterygidae												
Calopteryx				0.2								

(continued)

Table 17. Continued.

	Treated Site						Control Site					
	1986			1987			1986				1987	
Taxa	Spring	Before	After	Fall	Spring	Fall	Spring	Before	After	Fall	Spring	Fall
Plecoptera												
Taeniopterygidae												
Taeniopteryx				4.6		3.2				4.4		8.2
Strophopteryx				16.6		6.6	0.4			19.8		14.4
Nemouridae												
Amphinemura	0.2				0.4		0.2				0.2	
Ostrocerca	0.2	0.6			3.0	13.2	1.0					
Shipsa				4.0		0.2				3.2	4.2	8.0
Capniidae												
Capnia										3.2	1.6	5.6
Paracapnia		0.2		3.8		2.8					0.2	
Perlidae												
Neoperla	0.4			1.0	0.4		0.4		0.2			0.2
Paragnetina	1.6	6.6	4.8	3.4	5.4	4.8	1.6	0.6	0.4	1.0	1.2	8.4
Phasganophora	2.6	14.0	2.8	7.2	3.4	3.2	3.2	7.2	8.6	7.2	4.6	9.4
Acroneuria	5.4	10.4	5.0	16.0	6.8	7.6	5.8	5.8	4.8	10.2	6.4	12.8
Perlinella	3.6	2.2	1.6	3.6	2.0	2.6	3.6	5.6	4.4	3.4	2.4	9.4
Perlodidae												
Isoperla	17.4	0.2		12.8	26.0	19.4	18.0			7.4	28.6	13.8
Unknown	2.4	2.0	3.0	5.4	0.8	2.4	3.6	1.4	2.6	6.4	0.4	4.0
Megaloptera												
Sialidae												
Sialis	0.2											
Corydalidae												
Nigronia	1.8	5.4	1.6	0.8	1.8	2.4	0.4	1.8	1.4	0.8	1.6	2.2
Trichoptera												
Philopotamidae												
Chimarra	0.6	4.0		1.0		0.6		3.2	1.8	3.0	0.8	8.8
Dolophilodes	3.8	35.4	0.6	0.6		0.8	3.6	23.8	33.6	2.0	2.6	0.8
Psychomyiidae												
Psychomyia	2.4	1.6	1.2	0.6	0.8	0.2	0.2	0.4	0.8	0.2	0.4	0.4
Polycentropodidae								0.2				
Polycentropus		0.2		0.6	0.4	0.2			0.2			0.6
Hydropsychidae												
Ceratopsyche	60.0	171.2	93.8	83.6	38.8	53.2	44.6	154.2	90.6	55.2	45.2	126.2
Cheumatopsyche	14.2	6.4	5.0	19.4	11.0	9.0	8.2	1.6	7.6	18.6	11.2	17.8
Rhyacophilidae												
Rhyacophila	5.2	0.6	0.2	0.2	0.8	0.2	2.8	0.2	0.2	0.2	0.6	1.8
Glossosomatidae												
Glossosoma	18.0	22.8	6.0	108.0	23.4	75.2	13.2	3.0	5.2	54.8	30.6	20.0
Hydroptilidae												
Agraylea	4.4				7.6		9.6	0.2			3.2	0.4
Hydroptila	17.2	0.4		4.2	9.2	1.8	2.6	0.6		0.6	1.6	0.8
Leucotrichia	12.4	19.6	10.6	13.6	22.0	20.8	0.4	12.2	8.2	4.4	5.0	11.6
Stactobiella	3.2				9.8		15.8				2.4	

(continued)

Table 17. Continued

Taxa	Treated Site 1986 Spring	Treated Site 1986 Before	Treated Site 1986 After	Treated Site 1986 Fall	Treated Site 1987 Spring	Treated Site 1987 Fall	Control Site 1986 Spring	Control Site 1986 Before	Control Site 1986 After	Control Site 1986 Fall	Control Site 1987 Spring	Control Site 1987 Fall
Trichoptera (continued)												
Brachycentridae												
Brachycentrus		3.8	2.0	3.4	0.4	1.4		22.6	14.6	9.2		6.6
Micrasema	1.0	1.6	0.4	1.6	1.2	0.4	0.2				0.6	
Lepidostomatidae												
Lepidostoma	9.2	3.4	2.6	24.6	9.0	13.0	11.4	4.4	3.0	39.2	24.8	24.8
Limnephilidae												
Neophylax	4.6	0.6	1.0	0.6	2.8		2.8	0.6	0.2	0.8	4.0	0.4
Hydatophylax				0.2						0.2		0.4
Odontoceridae												
Psilotreta	6.4	11.6	7.8	3.8	1.2	4.2	3.4	10.4	9.8	6.0	2.8	3.0
Molanna										0.2	0.2	
Helicopsychidae												
Helicopsyche	29.4	41.6	24.4	1.4	21.4	3.8	10.0	43.0	54.8	1.2	16.6	3.4
Leptoceridae												
Ceraclea				9.2	0.2	3.8	0.6	0.2	0.2	3.6	0.4	4.8
Mystacides		0.2	0.2	0.4		0.2		0.2		0.2		
Oecetis	0.8	0.6	0.6	0.6	0.4	0.2	1.0	1.2	1.4	0.6		
Setodes	0.6	0.4	0.2			0.2	0.6				0.2	0.2
Pupae	9.0	18.0	11.0	1.4	0.6	3.8	2.2	17.4	18.2	2.4	11.8	8.0
Adults							0.4	2.4				
Unknown		1.0			0.2			1.2	1.2	0.2	0.2	
Coleoptera												
Psephenidae												
Ectopria		0.2			0.4		0.2		0.4	0.4	0.4	0.6
Psephenus	1.8	8.0	5.2	2.8	2.2	3.2	4.8	6.2	10.4	2.4	2.0	18.4
Elmidae												
Dubiraphia (l)		0.4		0.2	0.2							
Optioservus (l)	54.8	130.4	72.4	121.0	55.0	117.4	46.6	73.2	114.2	129.6	73.2	184.6
Optioservus (a)	54.4	72.4	43.2	35.8	39.2	19.0	18.2	20.0	36.4	14.8	13.8	26.2
Promoresia (a)						0.6						
Gonielmis			0.2	0.2								
Stenelmis (l)	6.4	4.6	3.2	3.0	5.6	0.4	4.2	2.4	2.4	0.8	8.6	2.0
Stenelmis (a)	11.8	14.6	6.8	3.2	5.8	2.0	3.8	4.8	6.0	2.2	3.8	3.2
Diptera												
Blephariceridae								0.2				
Tipulidae												
Tipula	0.2							0.2				
Antocha	30.0	23.0	26.2	29.8	12.8	6.2	6.4	10.4	7.4	7.0	10.8	20.2
Dicranota			0.4	1.4	0.2	0.8					0.4	1.8
Hexatoma	4.0	10.2	5.8	3.2	4.8	2.2	5.4	4.6	11.2	3.4	8.8	5.6
Ceratopogonidae	1.4	0.8	0.4	0.4	1.0	0.8	1.4	0.2	2.0		5.2	1.0
Simuliidae												
Ectemnia				0.2	0.2							
Prosimulium	15.6	0.6	0.2	21.0	10.4	7.2	47.0	0.2	0.4	3.4	93.8	10.2
Simulium	0.8	2.0	0.4		0.4		0.6	1.6	0.8	0.4	0.4	2.2
Chironomidae	178.0	544.8	286.6	481.8	303.8	149.2	181.2	517.0	585.0	260.6	381.4	413.6
Athericidae												
Atherix	45.2	97.4	57.6	46.2	37.2	18.8	9.4	10.8	14.4	10.8	8.2	8.8

(continued)

Table 17. Continued.

Taxa	Treated Site 1986 Spring	Treated Site 1986 Before	Treated Site 1986 After	Treated Site 1986 Fall	Treated Site 1987 Spring	Treated Site 1987 Fall	Control Site 1986 Spring	Control Site 1986 Before	Control Site 1986 After	Control Site 1986 Fall	Control Site 1987 Spring	Control Site 1987 Fall
Diptera (continued)												
Empididae												
Chelifera					0.2			0.4		1.6	1.6	0.2
Hemerodromia	13.4	9.2	7.0	6.4	10.0	2.8	11.0	10.2	24.4	4.4	17.6	17.4
Pupae	71.4	14.2	9.2		60.4	0.6	62.2	8.8	8.8		37.0	0.6
Adult	1.8	0.4	0.2		3.0	0.4	1.6		0.4	0.4	0.2	0.6
Miscellaneous												
Turbellaria												
Planaria	3.6	6.0	14.0	11.0	5.8	17.2		0.4		1.8	2.2	3.8
Nematoda		1.0	0.6	0.2	0.8	1.8		0.8	1.6			
Annelida												
Oligochaeta	12.6	31.6	32.0	19.8	18.4	23.8	6.0	9.0	6.0	3.0	3.6	5.8
Branchiobdellidae	2.8	10.8	3.2	10.0	0.4	0.8	2.0	19.6	5.4	6.6	3.8	0.4
Hirudinea												0.6
Isopoda												
Asellus									0.2			
Amphipoda												
Gammarus						0.2				0.2		
Decapoda												
Astacidae	1.4	1.2	2.8	3.6	0.4	0.2	1.0	1.8	3.0	2.0	1.4	1.0
Hydracarina	4.4	3.0	4.2	12.4	3.4	4.4	3.6	2.2	2.8	3.0	1.8	1.8
Gastropoda		0.4										
Physidae												
Physa	0.4	0.4	1.2	1.4	0.4	2.4		4.8	3.4	3.6	1.2	3.8
Hydrobildae												
Amnicola	0.4			0.2								
Pelecypoda												
Sphaeriidae												
Sphaerium	2.0	1.4	0.6	1.6	0.8	1.2	0.6	0.4	0.6	0.4		1.2
Terrestrial		0.8	0.4	0.4		0.4	0.4		0.2			
Pisces		0.8	0.8	0.8	1.0			0.6			0.4	0.6
Total	1251.8	1681.4	928.2	1865.8	1245.8	1169.8	825.4	1183.8	1289.8	1084.8	1274.2	1718.6
Total Taxa	71	73	65	78	76	74	70	72	69	70	74	72

[a]Samples from the Whitefish River in 1988 will be presented, upon completion of processing, in later annual reports. Several years of data are required to evaluate the effects of lampricide treatments on the invertebrate community in streams. Index areas will be sampled annually each spring and fall, and before and after application of lampricides in the year treated.

Table 18. Mean number of organisms from five samples taken by kick nets in riffle communities in the Sturgeon River in 1987 in areas that are periodically treated and in areas that are not treated (control).[a]

[The Sturgeon River, a tributary of the Cheboygan River on Lake Huron, was treated in October 1988; the control area is in the Boardman River on Lake Michigan.]

Taxa	Treated area (Sturgeon River)		Control area (Boardman River)	
	Spring	Fall	Spring	Fall
Ephemeroptera				
Baetidae				
Baetis	92.2	3.2	224.2	3.2
Pseudocloeon		3.2		1.0
Oligoneuriidae				
Isonychia		0.6		
Heptageniidae				
Epeorus		1.8	0.2	
Rhithrogena	42.2	24.8	29.8	1.4
Stenonema	0.4	40.2	1.2	1.6
Ephemerellidae				
Drunella	103.2		150.2	0.2
Ephemerella	25.8	214.0	300.6	230.4
Serratella	1.8	134.6	0.8	0.2
Leptophlebiidae				
Paraleptophlebia	0.4	4.6	12.4	5.0
Odonata				
Gomphidae				
Ophiogomphus			0.2	0.4
Plecoptera				
Pteronarcyidae				
Pteronarcys		2.0	0.4	1.0
Taeniopterygidae				
Taeniopteryx		4.4		49.0
Strophopteryx		6.8		1.8
Nemouridae				
Amphinemura			2.0	
Nemoura			1.2	
Ostrocerca	1.2	0.2		1.8
Capniidae				
Paracapnia				0.2
Perlidae				
Acroneuria		0.4		
Paragnetina		3.4	0.4	0.2
Perlinella			0.2	0.2
Perlodidae		0.2		0.2
Isogenoides		14.4	0.8	1.8
Isoperla	1.8	16.0	5.8	5.8
Unknown		7.0		0.8

(continued)

Table 18. Continued.

Taxa	Treated area (Sturgeon River) Spring	Fall	Control area (Boardman River) Spring	Fall
Megaloptera				
Corydalidae				
Nigronia	0.2	0.6	0.4	0.4
Trichoptera				
Philopotamidae				
Dolophilodes	0.2	76.2	0.2	1.0
Hydropsychidae				
Ceratopsyche	1.0	128.6	14.0	23.6
Cheumatopsyche				0.2
Rhyacophilidae				
Rhyacophila	1.4	2.2	3.6	1.0
Glossosomatidae				
Glossosoma		1.0		0.2
Protoptila	5.8	73.2	123.6	53.8
Hydroptilidae				
Hydroptila		4.2	3.2	10.8
Brachycentridae				
Brachycentrus		21.0	19.2	10.0
Micrasema	3.8	70.2	66.6	60.6
Lepidostomatidae				
Lepidostoma	3.6	11.4	12.0	15.6
Limnephilidae				
Neophylax	0.8		0.4	0.8
Helicopsychidae				
Helicopsyche	19.2	222.8		
Leptoceridae				
Ceraclea				0.2
Oecetis	0.2	0.6		
Setodes		0.2		
Pupae	0.6	1.0	1.4	0.2
Coleoptera				
Dytiscidae				
Hydaticus				0.2
Elmidae				
Optioservus (larvae)	76.2	448.2	81.8	36.0
Optioservus (adult)	38.0	166.0	37.8	28.0
Diptera				
Tipulidae				
Tipula	0.2			0.2
Antocha	1.0	58.2	1.0	7.6
Dicranota			0.2	
Ceratopogonidae				
Bezzia	0.2			0.2

(continued)

Table 18. Continued.

Taxa	Treated area (Sturgeon River) Spring	Treated area (Sturgeon River) Fall	Control area (Boardman River) Spring	Control area (Boardman River) Fall
Diptera (continued)				
Simuliidae				0.2
Ectemnia		1.6		
Prosimulium		4.8	2.2	0.6
Simulium		3.0	11.0	3.0
Chironomidae	3.2	497.0	118.0	531.4
Tabanidae				0.2
Athericidae				
Atherix	3.2	24.2	43.4	61.0
Empididae				
Chelifera	0.6	6.6	15.4	1.0
Hemerodromia	1.2	10.4	8.2	2.8
Pupae	1.2	4.0	23.0	15.0
Adult		0.2	0.4	0.2
Miscellaneous				
Turbellaria				
Planaria		7.4	0.2	0.2
Nematoda		0.6	1.0	0.2
Annelida				
Oligochaeta	29.2	110.2	84.4	38.2
Hirudinea				0.4
Isopoda				
Asellus	2.6	31.2	0.2	
Amphipoda				
Gammarus		2.2	1.4	2.4
Hydracarina	3.2	21.2	4.6	13.8
Gastropoda				
Physidae				
Physa		7.4	1.8	2.4
Hydrobiidae				
Amnicola	0.6	47.4	0.2	
Ancylidae				
Ferrisia		3.0	0.4	0.4
Pelecypoda				
Sphaeriidae				
Sphaerium		1.6	1.2	0.6
Terrestrial		0.4	0.2	
Pisces		0.6		0.2
Total	466.4	2552.4	1413.0	1230.2
Total Taxa	34	57	50	59

[a]Samples from the Sturgeon and Boardman rivers in 1988 will be given, upon completion of processing, in later annual reports. Several years of data are required to evaluate the effects of lampricide treatments on the invertebrate community in streams. Index areas will be sampled annually each spring and fall, and before and after application of lampricides in the year treated.

Table 19. Mean number of organisms from five samples taken in kick nets at sites downstream and upstream of the lamprey barrier in the Brule River, 1987-88.[a]

	Downstream site				Upstream site			
	1987		1988		1987		1988	
Taxa	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Ephemeroptera								
Baetidae								
Baetis	43.8	5.8	18.8	3.0	68.2	3.8	44.6	2.2
Pseudocloeon		2.2		1.6		1.8		4.6
Heptageniidae								
Leurocuta				1.8	1.8			0.6
Nixe								
Rhithrogena	5.8	35.6	4.6	14.0	4.4	11.2	10.2	11.2
Stenonema	2.6	78.8	2.8	28.0	4.2	64.4	2.8	37.4
Ephemerellidae								
Ephemerella	135.0	1187.0	218.8	195.2	686.0	2205.5	224.4	715.6
Serratella	11.2	173.6	9.2	96.2	23.2	166.6	6.2	119.8
Leptophlebiidae								
Paraleptophlebia	1.8	14.2	0.4	3.4	3.6	7.4		2.0
Ephemeridae								
Ephemera				0.8				
Odonata								
Gomphidae								
Ophiogomphus	0.6	10.6	2.6	7.4	1.2	18.0	3.4	15.8
Aeshnidae								
Boyeria	0.2				0.2			
Plecoptera								
Pteronarcyidae								
Pteronarcys	0.2				0.6	1.0	0.2	1.2
Taeniopterygidae								
Taeniopteryx		50.0		37.8		48.4		69.2
Strophopteryx		14.4		4.4		22.6		8.6
Nemouridae								
Amphinemura					0.8			
Nemoura	0.2	0.6			0.2			
Capniidae		0.2						
Paracapnia		5.2		2.4		0.2		0.8
Perlidae								
Paragnetina		0.2				0.4	0.2	
Acroneuria	5.2	20.0	3.6	12.6	6.8	19.0	8.8	22.4
Perlodidae								
Isogenoides				0.2				0.2
Isoperla	3.0	16.4	0.6	10.4	2.4	25.2	2.2	13.8
Unknown		2.2		1.4		1.0		
Hemiptera								
Corixidae		0.2						
Megaloptera								
Corydalidae								
Nigronia					0.4	0.4		

(continued)

Table 19. Continued.

Taxa	Downstream site 1987 Spring	Downstream site 1987 Fall	Downstream site 1988 Spring	Downstream site 1988 Fall	Upstream site 1987 Spring	Upstream site 1987 Fall	Upstream site 1988 Spring	Upstream site 1988 Fall
Trichoptera								
Psychomyiidae								
Psychomyia	1.6	4.0	0.8		2.0	5.4	3.6	1.6
Polycentropodidae								
Nyctiophylax								0.2
Hydropsychidae								
Ceratopsyche	11.4	206.8	6.0	44.2	17.8	165.6	11.8	156.0
Cheumatopsyche	0.6	36.0	2.6	15.4	1.8	7.0	2.4	14.4
Glossosomatidae								
Glossosoma		0.8				0.2		
Protoptila	151.2	555.0	497.2	279.4	67.0	223.6	247.0	502.2
Hydroptilidae								
Hydroptila	0.4	47.8	3.8	17.8	3.8	27.2	7.0	26.0
Leucotrichia	0.2	2.2	2.4	4.4	2.0	4.8	0.8	6.4
Brachycentridae								
Brachycentrus	0.4	7.4	1.6	2.0	5.0	8.0	3.8	11.8
Micrasema	0.6	3.8		0.8	18.2	4.0	0.8	1.0
Lepidostomatidae								
Lepidostoma	1.4	23.8	1.6	5.8	14.2	74.2	8.6	36.2
Helicopsychidae								
Helicopsyche	2.8	8.4	9.8	22.0	2.0	1.0	9.0	24.6
Leptoceridae								
Ceraclea		0.2	0.2			0.2	0.6	
Oecetis					0.2			
Setodes	0.8	13.0	31.0	6.0	1.2	6.8	17.8	19.2
Pupae					0.4			
Coleoptera								
Elmidae								
Optioservus (larvae)	17.8	248.2	11.4	145.6	28.2	122.8	6.8	149.8
Optioservus (adult)	4.4	7.6	2.6	33.2	5.6	4.0	4.2	22.6
Stenelmis (larvae)	1.8	0.4	0.8	0.8	0.8	1.2	0.6	0.4
Stenelmis (adult)			0.2			0.2		
Diptera								
Blephariceridae	0.6	0.2			0.6			
Tipulidae								
Tipula	0.2	0.8		0.8	0.2			
Antocha	3.8	66.6	4.0	26.6	13.8	66.2	17.8	57.0
Dicranota		1.2		2.4		1.2		5.2
Hexatoma	1.2	1.2	2.6	2.6	7.6	5.8	9.2	15.6

(continued)

Table 19. Continued.

Taxa	Downstream site 1987 Spring	Downstream site 1987 Fall	Downstream site 1988 Spring	Downstream site 1988 Fall	Upstream site 1987 Spring	Upstream site 1987 Fall	Upstream site 1988 Spring	Upstream site 1988 Fall
Diptera (continued)								
Ceratopogonidae	1.0	1.2	1.0	0.6	1.6	1.8	0.4	0.8
Simuliidae								
Prosimulium					0.8	0.4		
Simulium		0.8	1.2	0.6	1.8	0.6	1.8	0.2
Chironomidae	53.8	51.6	28.6	89.8	379.8	113.2	35.8	183.6
Athericidae								
Atherix	34.0	51.6	38.8	82.6	38	20.0	22.2	26.0
Empididae								
Chelifera	0.6	0.4			2.6	3.2		
Hemerodromia	2.4	3.8	0.8	1.4	7.4	8.0	1.2	2.4
Pupae	11.0	0.8		1.8	98.2	0.8	0.2	3.6
Adult					0.2	0.2		0.2
Nematoda	0.6				2.4			
Annelida								
Oligochaeta	15.0	51.8	2.2	38.2	38.4	2.6	0.2	27.0
Hirudinea						0.2		
Amphipoda								
Gammarus		0.2	0.2				0.2	
Decapoda								
Astacidae								0.2
Hydracarina	3.4	3.2		1.2	26.4	9.0	0.2	2.2
Gastropoda								
Physidae								
Physa			0.2			0.4	2.4	0.6
Ancylidae								
Ferrisia		8.6	3.0	32.4	0.2	1.8	5.2	20.0
Pelecypoda								
Sphaeriidae								
Sphaerium	0.4		0.4				0.4	1.2
Terrestrial	0.2							
Pisces				0.2				0.6
Total	533.2	3091.4	916.4	1279.0	1594.2	3487.8	725.0	2343.6
Total Taxa	41	50	36	44	48	51	39	48

[a]The Brule River was treated in 1986 and included both upstream and downstream sites. Future treatments should affect only the downstream site.